HELSINKI SCHOOL OF ECONOMICS (HSE)
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THE EXPECTATION GAME OF FINNISH ICT AND BIOTECHNOLOGY FIRMS

Systematic factors behind high technology company growth estimations

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ABSTRACT
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Objectives of the Research

This research aims to find out the systematic factors behind the high revenue expectations of biotech and information and telecommunication sector companies. The focus of the empirical research is on the R&D-intensive firms, which have known to present high estimates of growth in revenues and later on in earnings. The paper seeks to find out the impact of firm- and project-specific factors on the level of turnover expectations. In addition, past estimates are analyzed based on previous forecasts and the follow-up information. The study aims to seek answers to the expectation game in high tech industries and how the expectations have materialized. The ultimate goal is to discuss whether the turnover targets are realistic in Finnish ICT and biotechnology industries.

Data and Methodology

The econometric model is based on the data obtained from the National Technology Agency of Finland, Tekes. The data consists of revenue expectations of 256 ICT and 80 biotechnology R&D projects. The time period for ICT projects is 1.1.2003-31.12.2003 and for biotechnology projects 1.7.2002-31.12.2003. Multiple regression models are used to test seven hypotheses derived from earlier scientific research theories. In the latter part of the study the past performance of ICT and biotechnology turnover development is compared to the estimates given by the companies. The ICT sample is from Tekes follow-up data and includes 75 projects. In biotechnology, the history data is collected from those companies that are included in the 80 biotechnology R&D project holders studied in the first part of the research and who had projects accepted for Tekes funding in 1997-1999.

Results of the Research

The revenue estimations of ICT companies are unrealistic. Both the two econometric models constructed and the past performance of ICT companies' turnover development support the conclusion. The realistic level of company turnover estimates would be only 20-30% of the original estimates. In biotechnology the expectations have not realized yet but the estimates have shrunk in size and postponed with years. I found some support for venture capital involvement, past R&D costs, exports and hot market condition when company growth factors are considered. However, the most significant impact on company growth has future R&D investments.

Keywords

ICT, biotechnology, growth, estimation, technology, Tekes

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Helsinki, 25.7.2004

Kari Herlevi

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1. Introduction

1.1 Content and background

In the late 90's there has been a significant move towards technology in the global markets. This shift coincided with the rise of Internet, which ultimately linked the uprising of new tech companies with the Internet. The definitions of new technology companies were somewhat ambiguous and far from clear-cut. What they had in common was that they were young, often with little or no revenues and they were making substantial losses. Despite of this the new tech companies incurred extraordinary increase in value. The so-called Internet-bubble reflected the unrealistic growth presumptions of the markets. The high-tech firms tended to go in public earlier than was normally the case. Without established products and markets the challenge was the estimation of the expected cash flows. However, even though normally the estimation of the growth rate in revenues is easier than estimating operating margins and expected cash flows, there is quite a challenge in making realistic assumptions concerning revenue growth rates, especially when it comes to new high tech companies without a track record. Despite that the Internet-bubble era is over, there still lays the challenge of the expectations game in the early phase high tech companies. The larger portion of company value being from future growth potential, the vulnerable is the firm to shifts in the expectations about future prospects.

The focus of this research is on Finnish biotech and information and communication (ICT) sector companies and the systematic factors behind the high revenues expectations. The ultimate goal of this research is to find out whether the turnover estimations of Finnish ICT and biotechnology high tech firms are realistic and whether they are explained by the systematic factors used in this study. Especially high tech companies in their early phases have difficulties to benchmark their excellence against current and forthcoming market situation. Without established products and the lack of experience of delivering goods from R&D phase to markets there is quite often a lack of congruence in the target turnover levels and the present situation of the companies. Quite often the market analysis done by the companies are scant, without evident link to company strategy and the target is vaguely a percentage share of world markets. Acknowledging the evident problems in the high tech business and the high risk incorporated in it, it is justified to question whether the target turnover levels painted by the company CEOs are realistic.

Firms in these sectors are usually highly R&D-intensive. Hermans and Tahvanainen in their recent study (2002) have studied the characteristics of Finnish small biotech businesses. In their research the R&D-intensive firms reported "that the more their costs contained R&D expenses, the higher their growth prospects were." High R&D investments are important for future growth but probably not the only factor influencing company turnover estimations. From an investor point of view the high tech companies are interesting because the return of the investment could be extremely high when the "golden egg" is found. Venture capitalist (VC) could be seen as informed agents, which have the ability to identify promising start-ups. Naturally there is a quite a challenge for the venture capitalist to invest in right companies. Companies interested in getting venture investments need to present high turnover estimations to attract investors. Some of the companies might have the fundamentals right but some of the companies might not. High revenue expectations and VC investment could indicate a possible success story. In the finance literature the phenomenon is called the picking winners theory (Baum and Silverman, 2003).

Other systematic factor behind growth opportunities could derive its origin from internationalization, capital structure and prior turnover development of a company. Company growth prospects in small economies are usually related to export opportunities. There are also studies linking growth opportunities with the capital structure of a company. The negative relation between growth and leverage will be studied. In addition, the study aims to show that prior hot market condition (i.e. yearly increase in revenues) affect the CEOs view on future growth prospects.

This study seeks to find out the relevant factors behind high tech company growth prospects and build an econometric model to explain the estimated turnover levels of the companies. The aim is to test what proportion of the turnover levels estimated by the companies is explained by the models. The results obtained from the models will be used to find out the realistic level of turnover estimations in ICT and biotech. This study will seek differences and explain them in an industry level between ICT and biotechnology companies. ICT and biotech sectors are very different in nature and due to this they are very interesting groups for comparisons. The aim is to find out factors which could be relevant also in other business areas than in biotech and ICT. The data consists of 293 companies from bio and information and communication sector. The revenue expectations are project-based estimations. The data is gathered from the database of the National Technology Agency of Finland (Tekes).

The latter part of the study concentrates on analyzing the past performance of estimations from both industries. Data from Tekes is used to cover realized turnover performance of a smaller sample of companies from both sectors against their R&D project turnover estimations from past. It is shown how the past performance of companies support the results obtained from the econometric models.

This study contributes to the earlier scientific research on high tech company growth estimations with its combinatory approach of combining data of future turnover estimations with data on past performance of companies. To my knowledge only few academic studies have attempted this approach. The study provides also interesting information on company performance in two very important high tech industries in Finland. The data obtained from Tekes is unique in Finland and first time used for this kind of approach.

1.2 Motivations of the study

The motivation to do the study sparkled from the problems I confronted in my present work in Tekes. As a controller mainly in biotech industry – partly also in ICT - I was puzzled by the turnover levels presented by the applicants. The turnover levels targeted by the small and medium size firms were extremely high compared to the size of the firms. In many cases the target figures were backed by quite overall market analysis done by the company itself or a professional market analysis company. One obvious reason for broad but not so focused market analysis is that R&D intensive firms are quite young and they lack sufficient track record and the products they are developing - especially in biotech - are quite distant from the markets. The demands and the challenges of the markets are not forcefully present in the R&D phase. This means that the target turnover figures are not based on the fundamentals of the product itself but the overall success rate of similar companies or similar products. The risk inhibited in the R&D is not so often taken into the consideration also in the target turnover levels. Normally the companies present only the upside view of the possible outcome.

The companies might have the resources to do the R&D phase but they lack the experience or/and the resources to do the marketing phase needed for a commercially successful product. The company and project portfolio presented in this study include companies with high risk projects which naturally need to have high return profiles. The question I pose in the starting phase of the study is whether the target levels are realistic and do they have the fundamentals needed to back them up.

1.3 Objectives and research questions

The aim of this study is to find out the systematic factors behind small and medium size (SME) high tech companies' growth prospects. The study concentrates on few key input factors to explain the growth prospects of the companies. By constructing econometric models I will try to analyze the realistic levels of high tech companies' growth estimations. In the latter part of the study the accuracy of the estimations in both sectors are viewed against realized development with a smaller set of data.

The research questions to be answered are following:

1. Does firms with venture capital investment have higher growth estimates?

2. Are exports or export intensity[1] related to growth rates?

3. Does R&D costs or R&D intensity explain high growth estimations?

4. Does high solidity indicate high growth prospects?

5. Does hot market condition (actual revenue increase) imply high growth?

6. Does projected future R&D investments as such or when related to company balance explain high growth estimations?

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[1] Intensity is calculated by dividing the independent variable by the company size factor e.g. exports divided by total revenue or R&D costs divided by the company balance

7. Is company age related to growth prospects?

8. Based on history data, how has the estimations of biotech and ICT firms realized? Are the estimated turnover levels realistic?

9. How do the factors found differ between biotech and ICT sectors and what are the underlying reasons behind differences?

These questions will be answered by going through earlier scientific research and by testing the hypothesis created in accordance with the earlier research. The received results are later on discussed with the industry experts. The intention is to enrich the study via insights from the field and improve the understanding of the results. Also the dynamics behind the estimates are analyzed via a qualitative approach i.e. the turnover estimates are reviewed against the "Targeted business of the applicant" -section of the application where companies have analyzed the commercial potential of the projects

1.4 Structure of the study

The structure of the paper is the following. The next section will review the industry sectors in general. The aim is to have a solid understanding of the present situation in the biotech and ICT industry in Finland and also in a global scale. In addition, an attempt to further clarify the nature of the industries is made. The analysis of the industry conditions should first of all help to understand the unique characteristics of biotech and ICT sectors. It serves as a basis for analyzing the empirical results and also as a context for understanding the discussions with the industry experts.

In the third section I will go trough the related research theory in order to create the theoretical framework for the study. Based on the previous research the necessary hypotheses for the study are created. The forth section covers the description of the data and the methodology. In the methodology part the research design issues will be clarified. Finally the multivariate regression analyse is performed.

The first part of the fifth section will concentrate on validating and examining the results. The latter part of the findings will concentrate on analyzing how the project based turnover estimates and the realized total turnover of the companies in biotechnology has developed. In ICT the estimations of the turnover of a R&D project is benchmarked against the actual development of the turnover according to a follow-up data. Next, the nature of the expectation game in the industries is compared in relation to the received results.

Finally, the sixth section will conclude the study and present further research topics.

2. Industry overviews

The intention of the industry overview section is to build a background for the rest of the study. Both industries are described quite broadly due to nature of this study. The overviews aim at describing the present state of the industries and the special features they incorporate. Irrespective of the fact that the empirical part includes only Finnish companies, the industry overview is partly international in nature. Both industries are liable to global market forces.

2.1 Biotechnology

The term *biotechnology* is widely used in many instances. Biotechnology is more of a mixture of separate technologies than a separate science itself. For statistical purposes a single definition has been created in OECD in 2002: *"The application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services*" (Hermans and Luukkonen 2002). Word like *biotech* is truly a "buzz-word" used almost in any context. In this study it refers to companies that utilize biotechnological innovations in their own application areas or just as a shortening for the word biotechnology.

The paper of James Watson and Francis Crick 50 years ago on the structure of DNA has been considered as a beginning of modern biotechnology (OECD, 1999). Since those days the development of modern biotechnology has been sky-rocketing. Biotechnology or life sciences have been regarded as the new sunrise industry of the 21st century after the reign of information technology in the 1990s (Ernst & Young, 1998). The foundation of the first venture capital backed biotech company, Genentech, in 1976 has been considered as the starting point of commercial biotech industry. The early development of industry was controlled by the USA and particularly Silicon Valley, California. In 1980s biotechnology sector was gradually creating alliances with the big pharmaceutical companies. Last decade was the time for expansion, growth and legitimacy as companies succeeded to get products out of their pipelines (Arojärvi, 2001). Also initial public offering i.e. IPO window was open for biotech's, especially in the turn of the century. Year 2000 was a good vintage for biotechnology: high valuations were acceptable and there was funding appetite for technology platforms. Excitement of humane genome sequencing and impact of genomics prevailed and high cash burns and long period to profitability were acceptable and exits achievable

Years 2001-2003 have been difficult for the global economy in general. The hangover of biotech itself was partly due to lowered valuations, technology platforms being out of favour, IPO window closed, genomics showing no fast results, VC funding tightened in addition to global economy decline and uncertainty of war (Afganistan, Iraq). The road to recovery after three years of bear market is challenging but it is seen as the survival of the fittest. The high risk factors included in biotech were disregarded by some VCs; early stage investments demands high return rates. Growth prospects of too many companies proved to be unrealistic (Rushton, 2003).

The fundamentals for biotech business are however still positive. Companies are reaching profitability, overall market is recovering and IPO window is opening slowly. European biotech revenues have been increasing steadily for many years in a row. (Gillin, 2003) Market capitalization of biotech companies has increased almost 50 % from the end of 2002. The return of the bull market has brought back biotech valuations. Near term drivers have been product approvals and sales and earnings growth exceeding expectations (Ullman, 2003).

2.1.1 Industry dynamics

In the previous chapter the definition of biotechnology was discussed. In this chapter an effort is made to describe the industry dynamics in more detailed way. Burrill & Company, a life science merchant bank, has in their yearly biotech report divided the industry in a following way: Health care, Diagnostics, Nutraceuticals, Agbio and Biomaterials/Bioprocesses. This classification is quite clear and it will be used here as a framework for describing the industry dynamics. There are many other classifications like the ones of Lievonen (1999) and Oliver (2000). The division is usually made according to the type of industrial application developed or the technology used by the sector.

Healthcare and especially pharmaceutical industry have been quite commonly studied objects in biotech industries. The pharmaceutical sector develops new medicines against diseases. The drug discovery industry has potential to save lives and improve the quality of human life. Despite the successes in the industry many diseases remain as a mystery. The absence of cure increases healthcare costs and due to the aging of the population, the costs are ever-increasing. Pharmaceutical industry is dominated by the large pharmaceutical companies - also known as "big pharma". In many cases drug discovery phase is done by a small R&D-intensive company but due to their limited resources a licence deal with a big pharma company is usually necessary. The pharmaceutical research direct the way of the future business possibilities in the industry. The number of drug targets is expected to increase. All the drugs on the market target fewer than 500 human molecules. The sequencing of the human genome will increase this number to several thousands. However, the mapping of human genome is just beginning. The future of the industry lies not in the genes controlling the production of proteins that makes us humans than in understanding the proteins themselves. (Branbäck et al., 2001)

Diagnostics industry is divided into 5 major segments: Nucleic Acid Testing (NAT), Clinical Chemistry, Immunoassays, Whole Blood Glucose (WBG) and Tissue Analyses. The fastest growing segment of the diagnostics industry in 2002 was Molecular diagnostics. In 2002 more than one million genetic tests were done and it is believed that in 2006 that figure could rise to ten million. Molecular diagnostics can help to identify correct responders to a particular therapeutic, to test adverse reactions and monitor chronic illnesses. Growth of the industry is dependent on several factors: the development of genomics and proteomics, decreasing cost of drug development, better utilization of therapies, need to reduce adverse drug reactions and the new approach for personalized medicine.

The global nutrition industry, i.e. nutraceuticals is a mixture of sound science and consumer needs and the industry is growingly capturing the attention of people interest in wellness, health, fitness and diet. The growing awareness of healthy living habits, the aging of population and the self-interest of people wanting to control their way of life has together with rising health care costs inspired people to seek preventive measures. One of the biggest problems is obesity. 1.8 billion people worldwide suffer from it. Compared to pharmaceutical industry where researchers start first with science, in the nutraceutical industry the starting point is the unmet consumer need. However, the industry is from a scientific point of view also challenging. It is estimated that the functional food and dietary supplements market are growing approximately 8-10% per year. The industry has however a credibility problem because some of the products offered has not been backed by scientific rigour.

Agribusiness or Agbio has been in turbulence because of continuing debate over genetically modified organisms (GMOs), while the critics of European Union has kept GMO-based products out of the markets in Europe. Also the use of biopharming has been questioned for the same reasons as GMOs. Both methods are accused of potential contamination of traditional crops. The advocates of GMOs point out that genetically modified food could be the answer for third world malnutrition problems, even more so when population is increasing drastically.

The last industry sector according to Burrill & Company's classification is biomaterials and bioprocesses. The driving force for traditional and novel manufacturing processes of using biotechnology is to find alternatives for traditional petroleum and other chemical-based materials and processes, consumers demanding for stable and low cost alternatives for oil, gas and petroleum. Similarly, markets for biomaterials and bioprocesses are estimated to growth because of climate effects like global warming. Also by complying with Kyoto Accords new and stricter environmental rules are coming into force. Industrial biotechnology is called "The Third Wave in Biotechnology". The first wave included innovations in health care, the second innovations in agricultural biotech. The opportunities in the industry include bio fuels (ethanol, bio diesel, and hydrogen), bio-based materials, novel biocatalysts, polymers, medical biomaterials, tissue engineering and bio-absorbable products. (Burrill & Company, 2003)

2.1.2 Risks and opportunities of biotechnology[2]

Biotech industry has many typical features that need to be discussed before going to the Finnish biotech industry specific factors. Some of the most well known features of biotech are presented which should help to understand the industry itself. Biotech compared to other high tech industries has similarities but the dynamics of biotech has also some unique characteristics.

Technological risks. It has been said that being in the biotechnology is like riding a roller coaster. The industry is characterized as very challenging from a business point of view. For example in pharmaceuticals, drug development is a risky business with long R&D times (12-15 years) and an extremely high cost until the drug is in the markets ($500-600 million). The costs are related to strict regulatory policies of national drug administrations. The drugs are required to go through series of tests in humans before clearance to the markets. The drug development business normally requires big muscles so that the high failure rate of drugs is possible to endure. From investor point of view the industry is for the most cool-minded and patient and normally the break-even is not in the foreseeable future. The companies without any blockbuster products are normally making losses and the value-added lays in the company R&D pipelines. However, the magnitude of rewards is almost impossible to imagine when a break-through has been realized. In spite of possible blockbusters the technological uncertainty and the risk inherent in it is the most important feature of the industry.

Industry turbulence and centres of scientific excellence. The biotechnology industry is characterized by a very dynamic environment including big companies and small spin-offs from universities and large companies. Like in many emerging industries biotechnology is in its development phase. The young industry is incurring many entries and exits of companies moulding the look of the industry all the time. Biotechnology industry is closely linked with academic world not only through spin-offs but also through scientific collaboration.

Patenting and international regulation. Patenting is very important feature of the industry due to the nature of the inventions. Patents provide exclusivity rights for the product for a limited

[2] The classification adapted from Gustafsson (2000) and Arojärvi (2001).

time span. Patenting time affects product life cycle and cash flows obtained from products. First mover advantage is very important in the industry because of patenting. The average protection time is 20 years and when the R&D process normally takes approximately a decade the effective product life cycle is ten years. International regulation has a certain guidance effect on the industry through the approval policy of national drug administrations. For example, The Food and Drug Administration (FDA) in US is closely followed world wide in the industry when it comes to its approval policy of drugs. In EU European Medicines Evaluation Agency (EMEA) carries out regulatory system of monitoring and approving medicinal products.

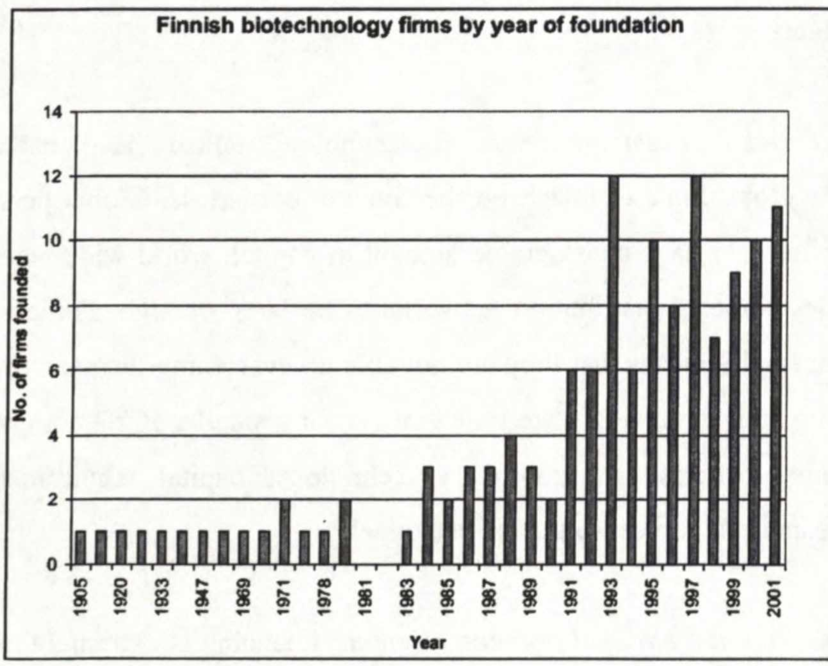
Global markets and high entry barriers. Biotechnology industry is global in nature. The problems of the globe from a biotech perspective are borderless. Global perspective means that companies need to have considerable amount of capital, world wide network of offices and a large sales force or distribution networks to be large enough. For a smaller biotech company this normally means that they are not able do everything themselves. Out-licensing of manufacturing and/or marketing are typical ways for a smaller R&D-company to proceed. Other high entry barriers are proprietary technology, capital requirements, access to distribution channels and access to skilled personnel.

Venture capital (VC) and national policies. Venture financing is extremely important factor in biotech because of long development times and high burn rates. VCs usually also guarantee an access to later stage financiers through their networks or carry the company until IPO is finalized. National policies and biotechnology are closely interrelated because of the nature of the industry. The promising outlook of the industry is making the governments increasingly interested in biotech. However, advances in science are making governments and societies in some cases also wary of the possible threats incorporated to new inventions.

2.1.3 Biotechnology in Finland

The study made by Hermans and Luukkonen (2002)[3] find out that by the end of 2001 there were 119 firms active in biotechnology in Finland (Fig. 1). In 2003 active firms numbered to 141 (Luukkonen, 2004a).

Figure 1.



Source: Hermans and Luukkonen (2002)

From a European perspective Finnish biotech firms have emerged later than firms in the UK, France, or so called Medical Valley i.e. Sweden and Denmark (Table 1):

[3] The study is based on a survey conducted by Etla and Etlatieto Ltd. The conducted survey represents quite well the total population of Finnish biotech companies.

Table 1.

The distribution of biotechnology firms in Europe by year of foundation

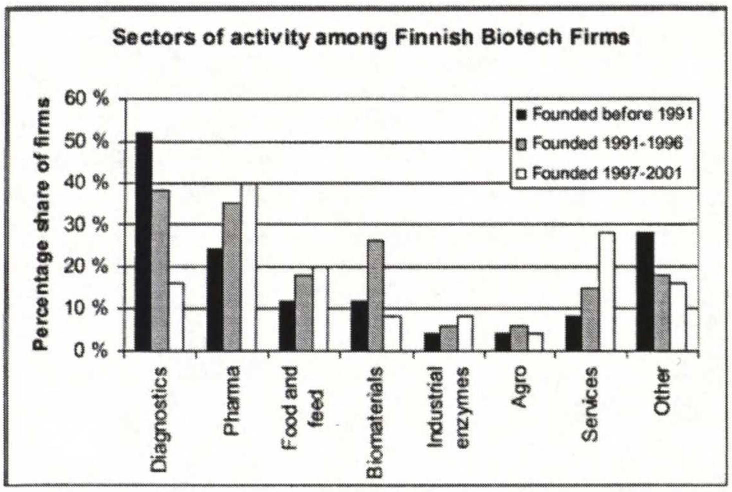
Founded	Finland	UK	Germany	France	Sweden	EU15
- 1991	26%	33%	20%	32%	38%	31%
1991-1995	38%	25%	23%	25%	26%	25%
After 1995	36%	42%	57%	43%	36%	44%
No of firms	105	448	504	348	235	1930

Source: Hermans and Luukkonen (2002)

From a geographical point of view the largest centres of biotechnology industry are in Helsinki and Turku regions. Other regional centres listed in magnitude are in Kuopio, Oulu and Tampere.

Hermans and Luukkonen find out that companies that were established between 1997-2001 67 % were spin offs from academia or other research institute and 19 % from another company.

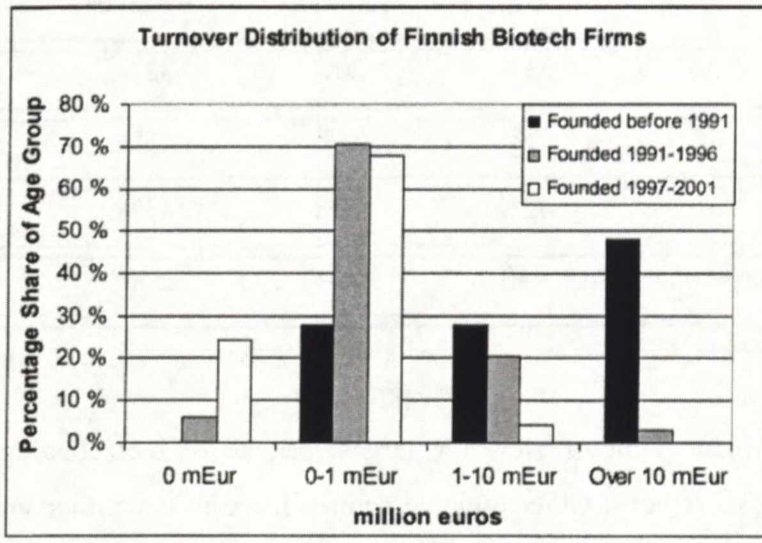
Figure 2.



Source: Hermans and Luukkonen (2002)

The Finnish biotechnology firms are most active in pharmaceuticals and diagnostics (Fig. 2).

Figure 3.



Source: Hermans and Luukkonen (2002)

Figure 3 is very good example of the current situation in biotechnology in Finland. The young R&D intensive firms are mainly making losses. However, the investments in R&D are expected to yield very high annual growth rates in revenues especially in the youngest cohort (Table 2).

Table 2.

Anticipated annual growth rate of Finnish biotech firms (weighted by firm size).

	Anticipated annual growth rate of turnover (5 years)
Founded before 1991	7 %
Founded 1991-1996	53%
Founded 1997-2001	114%
Total	10%

Source: Hermans and Luukkonen (2002)

The Finnish bio industry is in early stage of its development and the estimates given by the companies would indicate a lot of commercial potential. The overall sentiment in the industry is that major international deals are soon to be realized. Some activity to this direction was already occurring in 2003. Main part of the youngest firms has their products on a development phase and need still a great deal of financing until marketing phase. Limited resources of Finnish VC money mean that international venture financing is required in the future. Another important point is that the industry needs success stories, that is, companies reaching break even point to strengthen the credibility of the industry. At the moment there are only potential success stories. However, in spring 2004 good news from companies like Ark Therapeutics Ltd (IPO spring 2004) and Biotie Therapies Oyj showed that the R&D work done in the companies is valued in the markets.

2.2 Information and communications technologies

The role of information and communication technology (ICT) industry in economic growth has been in the spotlight for many years. ICT sector like biotech has been a hot topic; the driving force in both industries is high technology. Both sectors were in the forefront when stock markets soared in the late 90s. After the market hangover they have both suffered from the economic downturn. ICT's importance has grown in global economy but in spite of that the production, diffusion and use of ICT vary considerably between and also within countries (OECD, 2002).

The complete definition of ICT sector has been under development for years. In 1998 the sector was defined as a combination of manufacturing and services industries that capture, transmit and display data and information electronically. Manufacturing industries need to fulfil the function of information processing and communication including transmission and display. In addition they have to use electronic processing to detect, measure and/or record physical phenomena or control physical process. The service industries have to enable the function of information processing and communication by electronic means. (OECD, 2002)

2.2.1 Characteristics of ICT industries

The products or services of ICT industries are characterized by several factors. Products are usually complements. Consumers are usually shopping for systems. Complementary products mean also that the products should be compatible. Compatible products create a coordinated need for standards. The utility of the products are partly derived from the number of other people using similar products. Other industry specific factors are switching costs and lock ins.

Consumers are in many cases locked in to use a specific product and face switching costs if an alternative product provider is recognized. (Shy, 2001)

Software business. Software business is said to be a typical informational industry in which theories of product pricing do not apply (Shapiro and Varian, 1999). The developing and coding a product usually is expensive but reproducing and distributing is very cheap. Variable costs are usually very small; the cost of reproducing copies is very low. Software firms are generally independent of the hardware producers. The versioning of the core products is a distinctive feature of the industry. The future of the software business is said to be Internet based software. Software running on Internet is not required to be compatible with operating systems of computers. Increased accessibility and easier installation and upgrading are other advantages of the Internet based system. (Shy, 2001) The revenue of the software industry is estimated to grow 30% per year (Rajala et al, 2001).

Content and media. In spite of international products the content and media services are usually national in scope targeted to local consumers. Content and media produces services in electronic format or reproduces information utilized in the companies. Content and media provider owns products sold through networks. Contents are usually culture specific.[4]

Communication industry. Communication industry is the fastest growing industry in a global scale. The rise of the sector was due to progressive deregulation of telecommunication. Other significant factors were advances in the wireless technology and the progression of the Internet. Communication industry is a typical example of network externalities i.e. customers' decision to buy is dependent on the number of other users connected to the service. The critical mass of consumers needs to be reached before network effects increases. (Shy, 2001) The focus of communications industry is moving from technology to content provision. It is estimated that the next growth sector in the global ICT markets is content provision (Paija, 2001).

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[4] Osaamislinjaus 2004. Visioista osaamistarpeisiin – huippuosaamisella menestykseen, 2000. Tekes & SET. Helsinki.

2.2.2 ICT in Finland

"Helsinki is the Silicon Valley of Wireless Communications"
Carly Fiorina, CEO, HP (1999)

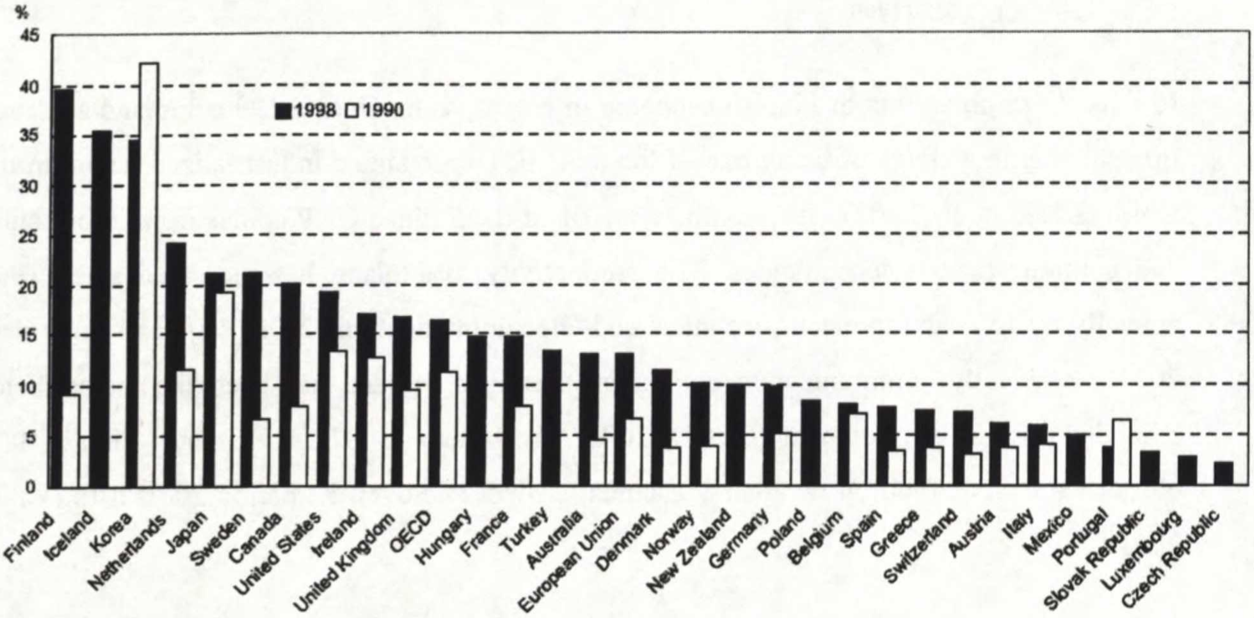
ICT has been an engine of Finnish economy in recent years. During 1990s Finland achieved in a short time a status of being one of the most ICT-specialized industrialized nation in the world (Koski et al., 2002). Approximately 10% of the Finnish GNP comes from information and communications technologies. The productivity of Finland has increased since 1992 annually by 15% and in electro-technical and telecommunications 25% (Paija and Rouvinen, 2003). Especially communication equipment sector in Finland has been the major factor behind the rapid development (OECD, 2002). According to ETLA estimates Finnish ICT cluster value added will grow at an 8% annual growth rate over the period 2001-2015 (Paija, 2001).

From an European point of view parts of UK, Germany, Switzerland and Italy are more focused on information technology (IT), while Finland (Helsinki) and Sweden (Stockholm region) are more focused on communication technology (Koski et al., 2002).

Figure 4.

ICT patents

ICT[1] patents as a percentage of total national patents filed at the EPO, for priority years 1990, 1998



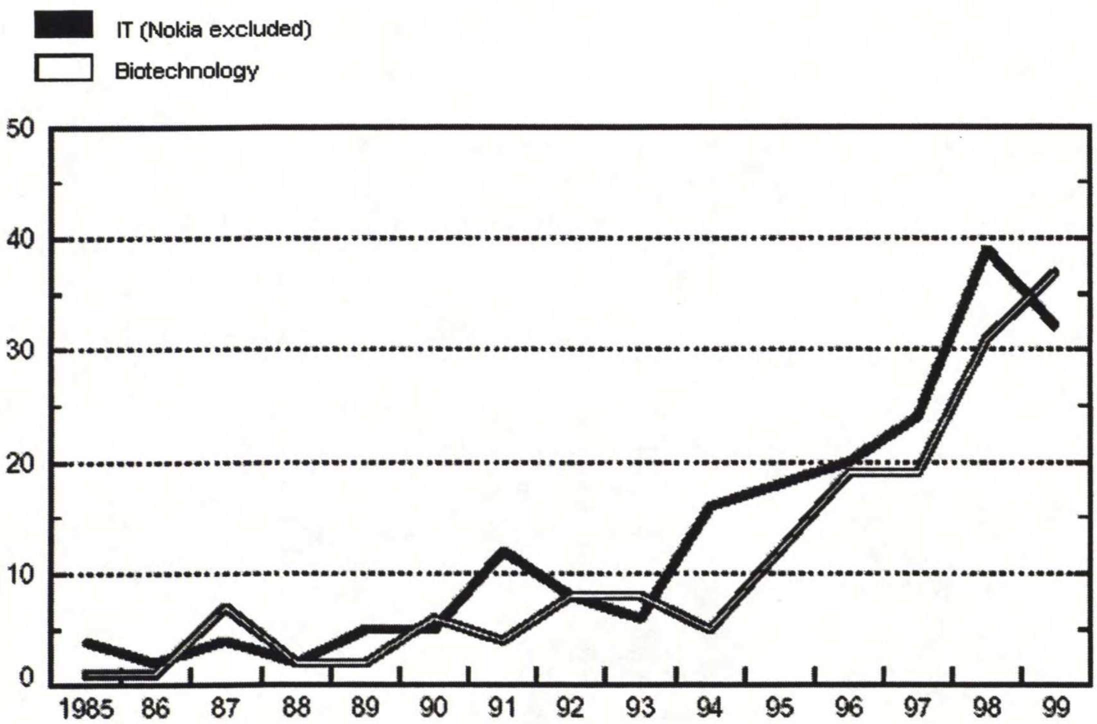
1. Classes of International Patent Classification: G06, G11 and H04.
Source: OECD, Patent database, March 2002.

As Figure 4 demonstrates, Finland has been very active in research and development in ICT sector from 1990 onwards.

On the other hand biotechnology and ICT do not differ that much when Nokia's effect is cleared from the statistics. In the next figure is shown the patents received in US in 1985-1999 where one of the inventors has been Finnish. Both sectors have received patents quite evenly.

Figure 5.

Finnish patenting in US (USPTO) in 1985-1999

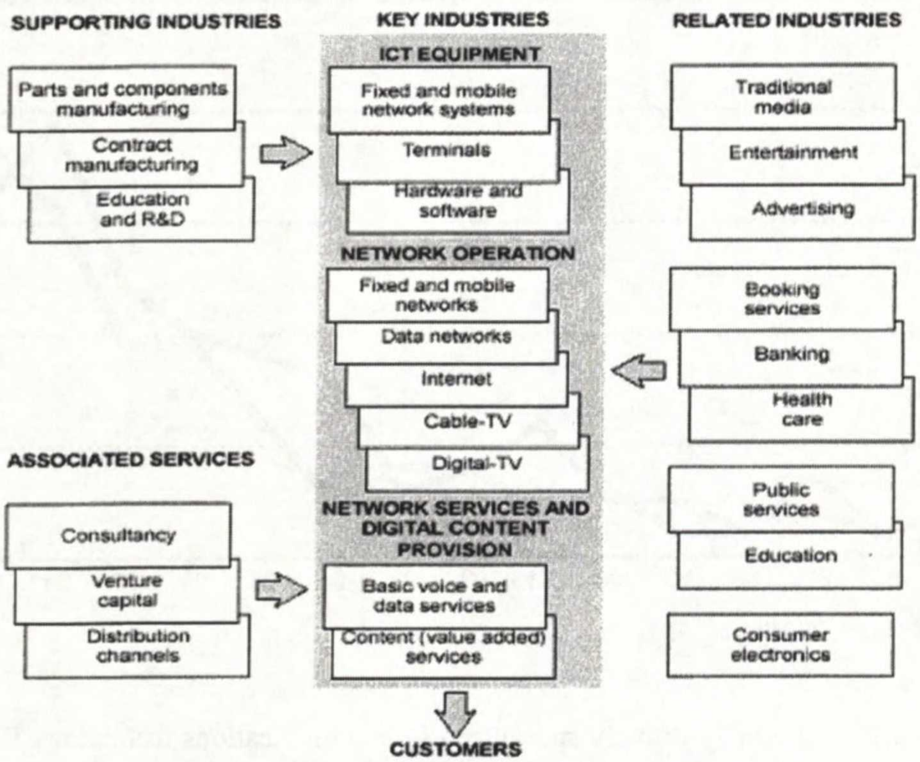


Source: Luukkonen, 2004b

The Finnish ICT cluster is strongly specialized in communications technology (Paija, 2001). Communications technology is dominated by one company in Finland – Nokia. The cluster incorporates several thousand firms over which roughly three hundred Nokia suppliers (Ali-Hyrkkö, 2001).

Figure 6.

Finnish ICT cluster chart



Source: Paija, 2000

In Figure 6 is depicted the Finnish ICT cluster. Around the key industries are those industries that are either supporting the cluster or somehow related to the industry. The Finnish supplier sector has focused on highly refined inputs while in standard components Finnish original equipment manufactures (OEM) rely on imports (Paija, 2001). Close vertical co-operation is distinctive for the cluster. Related industries produce complementary products. For example content providers are able to convert their products in digital format. Content providers also provide the packaging i.e. products are tailored to satisfy customer needs (Paija, 2001). Associated services are also included in the figure.

ICT cluster is under transformation because of convergence of networks, services, terminals and industries. Digitisation and deregulation are also shaping the face of the industry. (Paija,

2001) Fast expanding industry complicates the definition process of the industry. Companies are penetrating other business areas of ICT and are also creating new ones. Vertical merger and acquisition (M&A) activity is an active part of cluster dynamics.

Electronics and electro-technical industry's revenue in Finland in 2002 was 30.1 billion euros (Total ICT industry turnover was 46.8 billion euros in 2002). The industry includes following subcategories: telecommunications, consumer electronics and computers, components, electro-techniques, medical electronics and measurement systems and automation.[5]

The software industry reached in Finland 4.0 billion euros in revenues in 2002.[6] The industry includes two sub sectors: software products and data processing services. Lassenius et al. has studied the software enterprises in Finland. They find out that software companies seeking external finance had higher growth expectations. In 2000 there were some 700 companies (450 in 1999) developing software in Finland. 80% of ventures were located close to technology centres. The average age of a software company was nine years. Almost 80% sold their software for 850 thousand euros or less a year. (Lassenius et al, 2001)

Content and media business in Finland reached 6.4 billion euros in 2002. The industry includes following sub sectors: digital media, printing and publishing, TV and radio, audio and video and advertising.[7] Companies in the industry vary from content and service providers to Internet portals. Services are provided via Internet ever increasing pace and in the same time making classifications in the content providers industry more difficult. In Finland digital media production technologies are in their early stages. (Paija, 2001)

[5] Unpublished information. Obtained from the database of Tekes, document number 33606.
[6] Unpublished information. Obtained from the database of Tekes, document number 33606.
[7] Unpublished information. Obtained from the database of Tekes, document number 33606.

3. Theoretical framework and hypothesis

This study draws its ideas from rich sources of corporate finance. The study will focus on a few relevant theories from the field. In addition, theories from venture capital (VC) are reviewed. VC related theories are considered many times as extensions of corporate finance. On the other hand, venture finance is seen as a multidisciplinary field of research with various components from other disciplines. Venture financing is closely related to the studies of entrepreneurship. (Pekkanen, 2002) Entrepreneurial finance is sometimes defined as a subcategory of corporate finance in terms of phase of financing i.e. financing through seed phase to IPO (Virtanen, 1996). The description of entrepreneurial finance is very useful when searching for differences between public and private companies. Table 3 shows clearly how the private companies studied in this thesis differ from the public companies and how challenging the analysing of the private companies is.

Table 3.

Characteristics of entrepreneurial and corporate finance market and companies

	Corporate finance and companies	**Entrepreneurial finance and ventures**
Market	• markets are informationally efficient • transactions take place continuously • efficient information => risk and return directly related	• market inaccessible, unorganized and often invisible • very few transaction during the entrepreneurial phase; prices not quoted daily • defies the direct relationship of risk and return
Financing	• changes in overall financial status usually low • amount and cost of money optimized • capital is anonymous	• changes in financing volatile • value creation in the long run • milestone based to reduce risk • capital earmarked
Valuation and Accounting	• accrual based	• Cash flow most

	accounting, EPS • sophisticated valuation methods based on large amount of data • Assets-in-place type financial ratios	important • the most valuable assets are intangible assets and growth opportunities • monitoring costs are related to human capital benefits • valuation of the firm based on intuition and qualitative data than on computer modeling
Value added	• does not include any other values than money and capital • share price as a decision parameter	• financing, especially external equity, creates value added other than money (trustworthiness, credibility, know-how, resources, etc) • commitment shown by equity participation, personal wealth and intensive effort
Goals and objectives	• maximize quarterly/semi-annual/annual earnings	• main goal: create value in the long run
Management and control	• separation of the management and control • ownership dispersed • scarce hands-on possibilities	• management and control inseparable • ownership more concentrated • hands-on practises common

Source: Virtanen, 1996

Next chapter begins with a brief overview on key corporate finance theories related to this study. The theories will be analyzed further in connection with the research problem presented in the introduction chapter. Theories will be analyzed also in the context of the two key industries studied. Based on earlier studies I will present 7 hypotheses. These hypotheses will be tested in the empirical part of the study.

3.1 Agency theory

Agency theory is well known theory in finance. Agency theory describes the relationship between a principal (e.g. stockholder) and an agent (e.g. manager). An agent agrees - against a payment - to do tasks in favour for the principal. Originally the agency theory was found in 1932 by Berle and Means, who discovered that the reduction of management's ownership in some cases reduced the willingness of the management to strive for longer term profits in favour for short term profits. Jensen and Meckling (1976) have stated that the principal-agent theory is found in all organizations and in all co-operative efforts in every level of management.

The focus of the research has been on larger public companies. In the US the ownership of major corporations is widely dispersed. The lack of control has driven owners to seek ways to tie the management's compensation on the value they have added. In some other countries like in Germany the ownership of companies is not so dispersed. Companies are owned by a few major institutions like banks and they can review the situation of the companies more like the company insiders do (Brealey and Myers, 2000). Situation in Finland resembles the situation in Germany but basic questions of agency problems are still valid also in an European context. The two key problems in agency relationships are agency problem and problem of risk sharing. The former is composed of two categories: (1) Agency problems that arises from conflicts between principal and agent on goals, (2) problems on verifying the doings of an agent in a setting when close follow up is difficult or it is very expensive. The latter problem consists of a situation where the principal and agent have different attitudes towards risk. (Eisenhardt, 1989) From an entrepreneurial point of view conflicts could consists of lack of congruence in strategies, research and projects that are highly rewarding for the entrepreneur but offers low returns for the venture capitalist (Gompers, 1995). In the field of high technology, which is based on latest scientific knowledge there is a possibility that the entrepreneur has self-serving goals like scientific reputation. In some cases the research done is too far from being commercially applicable, yet very interesting from a scientific point of view. Agency costs are easily recognized when for example biotechnology companies are in question. Venture capitalist might have difficulties to understand whether the company is doing the right things e.g. not continuing the basic research from university under VC finance.

One underlying reason of agency costs is *asymmetric information* i.e. the different level of information between the management and the investors. Investors are not usually involved in the daily activities of the company. Of course one of the most crucial phases is the initial investment of the investor. Before investing the investor incur direct and indirect costs e.g. in form of due diligence costs. Also post-investment phase has agency costs. The entrepreneur might take too risky projects or be satisfied with a low return projects. The investor has normally an exit strategy that requires certain milestones to be achieved and due to agent's *moral hazard* (lack of effort) the goals could be endangered. *Adverse selection* problem means in VC context for example that only the least desirable entrepreneurs offer their business ideas to investors. This could result from a situation where investors find it difficult to recognize the potential investment targets from the least desirable (Gompers and Lerner, 1999). For example a scientist could claim to have experience in a certain scientific field and the investor cannot verify the claims (Eisenhardt, 1989). Leland and Pyle (1977) were among the first to propose that even positive net present value projects could be hindered by asymmetric information. The problems are most difficult in the early stages of company development. It is suggested that asymmetric information problem could be at least partly above firm-specific variables. In industries with unproven future prospects, changes in asymmetric information surrounding individual firms might be positively correlated. This was true in biotechnology in the US in the 1980s and in electronic commerce in the 1990s. (Lerner et al., 2003) In other words, an evaluation of a company could change due to new information concerning another company in the industry. High opacity of the firms is one reason why companies might have pressures for *self-selection* i.e. firms with high growth prospects and limited financial information might choose for high quality disclosure e.g. prestigious auditors (Hyytinen and Pajarinen, 2002)

According to Gompers (1995) the structure of financing would be irrelevant if the agency costs and asymmetric information did not exist. Investors would allocate money quite freely and entrepreneurs would feel free to use it as they prefer.

3.2 Intangible capital

It is widely accepted that research and development (R&D) investments contribute positively to economic growth. Since the studies of Schumpeter (1942) an impressive amount of literature has been accumulated on the subject. Lately there have been more and more questions concerning how the market value of young technology firms is determined. It is evident that the determinants of growth opportunities for emerging firms need to be studied. ICT and biotechnology firms are different from the brick-and-mortar enterprises in many ways. For example, they generate negative earnings and may have no production utilities for several years. However, only few academic studies have attempted to measure or explain their market capitalization (Garner et al., 2002).

One used hypothesis is that firms with higher intensity of R&D investments relative to the industry averages are more likely to have higher market value of growth opportunities. The reason behind this is that they are expected to win the race to innovate. Very often in the financial literature Tobin's q i.e. the market value of the firm divided by its replacement value is used as a proxy for the market value of the firm's growth opportunities. For private companies the market value is difficult to define and so the use of Tobin's q is less adequate. The research of Garner et al. (2002) showed that the larger the relative R&D investment, the greater is the market value of the firm. The results were in line with their theoretical prediction of firms with higher speed of innovation being higher valued in the market. Firms are highly motivated to carry out R&D because they are after for monopoly profits that can be achieved when a patent is accepted.

The study of Darby and Zucker (2002) argued that the biotech firms with the deepest science base will be the most successful in financial rounds and in the same time achieve sufficient R&D success. They also argued that more funding would be directed to firms where the star scientists were involved in base level science and not only authorizing their name to be used in a scientific advisory board. Proxies for a firm's science base were the number of articles written by star scientists, granted patents and whether or not a firm uses rDNA technology.

They found that strong science base increased the likelihood of a company to go public. They also interpreted the results so that the involvement of a star scientist in a company is more likely to bring venture capital financing.

3.3 Capital structure

There are many studies on capital structure. The modern debate on the capital structure choice originates from the theory of capital structure irrelevancy proposed by Modigliani and Miller in 1958. The theory suggests that the choice of capital structure should not matter. In perfect markets changes in capital structure do not affect company value as long as the total cash flow generated by the firm's assets is unchanged. The value of the whole should be left intact irrespective of the fact how it is sliced. (Modigliani and Miller, 1958) In their partial equilibrium analysis both companies and individuals can lend and borrow without limits. The model is a simplification, for instance the effects of taxes, agency costs, financial distress and asymmetric information are not included.

According to Harris and Raviv (1991) the capital structure theories can be divided into five categories. Tax-based theories emphasize the importance of interest tax shields. The second category includes the agency cost considerations concentrating on a) principal-agent conflicts or b) conflicts between equity and debt holders. The third approach attempts to find a relation between a firm's capital structure and the input or output markets. Forth approach is asymmetric information category that deals with signalling effects in the capital markets and the effects of adverse selection on it. Finally, the fifth group concentrates on issues related to corporate control.

Capital structure decisions have been explained in small business studies by the *pecking order hypothesis* (Virtanen, 1996). Pecking order hypothesis suggest that firms prefer internal financing. If external finance is needed, firms prefer debt and hybrid securities before equity. This theory explains the debt ratio within industry because less profitable firms have to borrow in order to keep up with the growth of their industries. It is less successful when explaining interindustry differences. For example debt ratios are usually low in high technology and high growth industries even when external finance is needed. (Brealey and

Myers, 2000) Brealey and Myers remark that companies facing significant costs of financial distress might not follow the pecking order hypothesis.

A partially reversed pecking order theory implies that VCs have invested before banks and other financial institutions (Hyytinen and Pajarinen, 2002). Firms resort to outside equity finance before they can obtain significant amount of debt. In Finland especially biotechnology firms are heavily financed by external equity. Also *the trade-off theory of capital structure* states that the target debt ratio varies from company to company and industry to industry. There exists a trade-off between the interest tax shields and the costs of financial distress. Unprofitable companies with intangible assets ought to rely on external equity financing and more mature companies with tangible assets and taxable income should have high debt ratio in order to utilize tax shields. (Brealey and Myer, 2000)

3.4 Company growth

Generally, it can be said that the growth of the firm is the expansion of its activity[8]. However, there is no single, generally accepted measure of firm growth. It is usually measured by the number of employees, the amount of capacity, the amount of total assets, the annual sales, sales margin, operating margin or market share. All these measures are surrogates of the activity of firm. (Kanto and Tuovila, 1987)

The concept of gazelle was introduced by David Birch in 1979. A gazelle is a small or medium-sized company with an explosive potential and an ability to sustain rapid growth. A more detailed definition states that gazelles are firms with at least 20% sales growth every year. The starting level of sales has normally been at least $ 100,000. (Gregory, 1998; Case, 1996) As a by-product of his research Birch found that small firms created 82% of new jobs. This was in sharp contrast with earlier studies. Gazelles accounted for more than 70% of the growth in the US between 1992 and 1996. Of the entire firm population gazelles represented only about 3%. They were found in all industries but only 1.8% of gazelles were found in high-tech industries. (Birch et al. 1997) An OECD study has found that less than 20% of new firms achieve rapid growth. The majority of firms maintain their initial turnover, number of

[8] Often called the size of the firm

jobs and market share or downsize. In contrast to Birch's et al. findings they found that high-growth firms operated in the medium-to-high and high-tech sectors and in industries dominated by large companies. In addition, exports had a positive correlation with growth. (Julien et al., 1998) In a Finnish study of gazelles, Ere Vakkilainen (1999) found that in general high-tech industries had high-growth firms. The time span of the study was 1994-1997, which includes very good years for Finnish ICT-sector.

Not all studies support the view that high technology firms are growth oriented. For example Kamshad and Hay (1996) found that the management goal in the new technology-based firms is profitability instead of growth.

3.5 The influence of a venture capitalist on company growth

> "You can compare receiving the venture capital investment as a situation where you place a turbo engine in an ordinary machine. This will make the increase of the speed of revolution possible. In agrarian terms, a venture capital investment is like fertilizer: it costs something, but creates faster growth when added."[9] - One entrepreneur view of venture capital finance.

From the days of Berle and Means (1932) a lot of attention has been put on the company owner's ability to look after and influence the actions of executives. The mainstream of the research has focused on large public companies. However, there are studies were the corporate governance problem is said to apply also to smaller companies with less dispersion in ownership (Eisenhardt, 1989).

Governance measures are possible to define in many ways. One way is to divide the governance measures in two groups: active and passive. Passive measures are typically compensation schemes, contractual covenants and strict reporting requirements. Active measures require frequent involvement from the investor. (Pekkanen, 2002) It is very common that in spite of the governance measure used, venture capitalist sit on the boards of directors. An active role could for example include following activities: help recruit key

[9] Virtanen, 1996.

personnel, negotiate with suppliers and customers, aid in strategy formulation, raise additional capital and help in M&A activity (Pekkanen, 2002).

In a number of studies of venture capital involvement and value added, the results tend to be merely descriptive and atheoretical (Sapienza, 1996). Gorman and Sahlman (1989) found that the level of investor involvement varies markedly. For example Rosenstein (1988) shows that venture capital investors are more involved than outside shareholders in public companies. MacMillan et al. (1988) state that the level of involvement is determined by a personal choice. MacMillan et al. claims that active investors feel that they have managed as well or bad as those who are passive. Ehrlich et al. (1994) found that there is no difference between private investors and venture capitalists in activities they are involved.

Virtanen (1996) has studied the Finnish venture capital environment. He states that venture capitalists add value in small economies by assisting in the internationalization process of companies. Growth opportunities in small countries require foreign purchasing power. Virtanen states that companies seek venture capital to increase their credibility. Other forms of value added in Virtanen's research are networks, financial consultancy, general management, collateral offerings and acting as a sounding board.

Attitudes of entrepreneur and venture capitalists towards venture capital decision making process might diverge. For venture capitalist an investment decision may be a portfolio selection problem although studies support more specialisation than traditional portfolio selection problem (Norton and Tenenbaum, 1993). For an entrepreneur the situation might be more like a dynamic growth problem. Virtanen (1996) refers to an "all-or-nothing bet" in entrepreneur's case and in VCs point of view there are several bets. In his case study some of the entrepreneurs commented the VC involvement by saying that the VC investment made possible riskier projects and paved the way for higher growth. Virtanen states that theoretically a firm chooses a venture capitalist only if 1) the overall growth of the expected market value of the firm during the investment period is larger than it would be without VC investment (venture capital advantage) 2) the firm *ex ante* presupposes to be able to utilize some of it. The venture capital advantage is calculated as a cumulative sum of net cash flows over the entire investment period. However, in spite of the growth opportunities included in the VC investment, it is argued that since the venture capital is very expensive[10], why the most promising companies should resort to it. In many cases the involvement of a VC is justified by getting something else than just money (Timmons, 1994).

The asymmetry of the information between the entrepreneur and investor might lead to a situation were the agent tries to window-dress or exaggerate the success or potential success of projects (Leland and Pyle, 1977). High growth estimations of the companies might indicate also something else than CEOs pressure to communicate only up side view of the company to the investors. Venture capitalist could be seen as informed agents that have the ability to identify promising start-ups. Baum and Silverman (2003) call the phenomenon as the picking winner's theory. Venture capitalists could be seen also as building winners. Baum and Silverman argue that the coach aspect could be disentangled from picking winners theory by analyzing differences in revenue estimations. If the company estimations are low, the venture capitalist is still building the winner. The problem with this kind of research is that both aspects are usually positively associated with start-ups' future performance. The difficulty to disentangle these two effects is probably one of the most obvious reasons why the research literature is scarce.

Venture capitalists are after high returns since the risk included in the start-ups is very high. They are interested in possible success stories with high growth opportunities. Do the companies forecast higher growth prospects when venture financing involved? Is the possible turbo-effect seen from the project specific turnover estimations? Based on the literature above I put forward the first hypothesis:

H1: The revenue estimations of the companies with venture capital involvement are higher than in companies without VC investments.

Virtanen (1996) stated that growth opportunities in Finland require internationalization. The second hypothesis is following:

H2: The higher the exports or the share of exports of company turnover, the higher the growth prospects are.

[10] rf. pecking order theory earlier on in Chapter 3.3.

3.6 The solidity against company growth

Generally it is assumed that the optimal capital structures are closely related to the growth potential of the firms. Capital structures of firms are also related to the size of the firm and to the industry characteristics. (Chen, 2002) Harris and Ravivin (1991) argue that high solidity, that is low leverage, implies high growth rates. The studies they reviewed generally agreed on the negative relation between growth and leverage. The inverse relation between leverage and growth is that growth opportunities usually are intangible assets that have low or zero collateral value and due to this firms have to rely on lower leverage (Tilman and Wessels, 1988). Many times high tech firms can be credible issuers of common stock because their bankruptcy of financial distress would be extremely costly (Brealey and Myers, 2000). Growth firms lack also taxable earnings needed to make use of interest tax shields.

Building on the argument above, leverage is negatively correlated with high growth rates, and positively correlated with low growth rates. Thus, third formulation of hypothesis is following:

H3: The higher the solidity of the company, the higher its growth prospects are

The results should imply that the growth opportunities may influence the capital structure.

3.7 R&D as a growth factor

In Chapter 3.2 of intangible assets few important aspects of positive impacts of R&D investments on company growth was discussed. The evidence from Finland (Hermans and Tahvanainen, 2002) and abroad (Garner et al., 2002) indicate that intangibles should be taken seriously. To illustrate the role of intangibles in economy one need to only remind that in US e.g. in 2000 private US firms invested at least $ trillion in intangibles. (Nakamura, 2003) Bearing in mind the arguments for the relevance of R&D expenditure I bring forward the forth hypothesis of R&D investments:

H4: The higher the annual R&D costs or R&D intensity, the higher the company growth prospects

3.8 Hot market condition

Darby and Zucker (2002) studied the factors influencing biotechnology companies going public. One of the independent variables explaining the increased likelihood of biotech company initial public offering was so called "hot market" condition indicated by prior high returns. They found out also that a prior hot market increased the expected amount of money that the firm will raise if going public. I will use the idea of hot market condition in explaining high growth prospects. In this study the hot market condition is in effect if company's actual sales have increased. Is prior hot market related to CEOs view on future growth prospects?

H5: The higher the actual revenue increase, the higher the growth prospects in the future

This formulation is invalid for many biotech companies because many of the companies do not have revenues. A special group are gazelle companies. The hot market condition is presupposed to be strongly operating when a company is considered to be a gazelle company i.e. the company revenue has increased 20% or more per year for three years (2000, 2001, 2002) or if for some reason data was available only for a shorter period (company established later on etc.) the longest period possible between 1999-2002 is utilized. The starting level of sales has to been at least 100,000 €. The study will also shed light to the controversy whether high tech firms are really growth oriented or not.

3.9 Future research and development investments

Previously, arguments for the including of past R&D costs as a variable explaining company growth were justified. If past R&D costs are relevant, then should also future R&D investment be relevant. As a future R&D investment, the study will use as a proxy the project specific estimate of R&D costs. In fact, it is more than a proxy in a study context because it states the R&D investment needed to achieve the project specific target turnover estimate used in this study as a dependent variable.

H6: The higher the estimated future R&D expenses of the project or the higher the future R&D project investments divided by company balance, the higher the growth estimate of the firm

3.10 Company age

Are younger companies eager to grow faster than elder counterparts? Earlier research supports the notion that from the two industries under examination, the biotech business in Finland is in a phase were younger companies are bold in their future views. Hermans and Luukkonen (2002) found that the highest anticipated growth rates of biotech firms were from the youngest age group (founded 1997-2001). However, also in general the biotech field aims to grow faster than the economy as a whole while even the oldest companies (founded before 1991) anticipate growing 7% annually.

H7: The younger the company, the higher its growth prospects

4. Methodology

In this chapter the methods of collecting and analyzing the data of company growth estimations is presented. The chapter starts with an overall presentation of the data, which will serve as background information and it should give a reasonable understanding of its quality. I show descriptive statistics of the data to convey a good understanding on the nature of the firms and their projects in the sample. I will also describe the interviews conducted during the research. Also the data of the latter part of the study is introduced. After that I will present and explain the dependent variable and the multitude independent variables used to test the hypotheses. Finally, I present the regression models used in the study.

4.1 Description of the data

The main part of the data is collected from the database of the National Technology Agency of Finland (Tekes). Tekes is the most important public financier of business R&D in Finland. The agency promotes the competitiveness of Finnish industry and the service sector via technology. Tekes provides funding and expertise also to universities, research institutes and academic institutions.

The data obtained from Tekes was semi-structured from the study perspective. The data consists of revenue expectations of 256 ICT and 80 biotechnology projects. The time period over which the *BIO* data is collected is 1.7.2002 - 31.12.2003 and for *ICT* data 1.1.2003 – 31.12.2003. The revenue estimations are project based estimations since Tekes is interested in collecting data of the projects they are partly financing. Growth estimations are made by the applicants but there is also a reality check done by the experts in Tekes. The applicant company has to estimate not also the revenues in question but also the timing of revenues i.e. the year when the project outcome (product, service) will be on the market plus two subsequent years and the target year when revenues are highest.

The data includes also basic company financial information, e.g. company revenues, earnings before interest and taxes (EBIT), earnings, exports, R&D expenses, number of employees, share capital, shareholders equity, total assets, quick ratio and the ownership share of a large company. Semi-structured information is found from the project appraisal memorandums. For example, the involvement of venture capital investors is possible to find out from these files. Likewise, the ownership structure is in many cases described on these files.

The sample of Finnish high technology companies consists of two sub-samples - ICT and biotechnology companies. The two sub-samples will be reviewed separately but the sample is analyzed also as *ALL DATA*. Differences between the two sub-samples might originate from the sector specific factors described next or from the differences of independent variables explaining revenue estimations in each sub-sample.

ICT and biotechnology companies were selected because they are truly high tech industries and both are seen as very prominent from a Finnish perspective. Especially ICT is already proved its potential. Biotechnology is still in its infancy but the activity in the industry is at the moment (2004) remarkable in Finland. Public R&D investments in biotechnology are notable and the industry is one of the main activity areas of Tekes. Both industries are quite young and they have sprouted many young high tech companies with high growth potentials.

The data used in the latter part of the study for comparing the actual and estimated development of turnover in both industries is described in the findings (Chapter 5.3) section but some information of the data is given already here. The ICT sample (N=75) is from a follow-up data of Tekes for the projects which ended in 2000. In spring 2003 1827 questionnaires was sent. The response rate was quite high (70.2%). The aim of the follow-up studies is to have information on how the projects have developed after the companies have submitted the final report to Tekes. The ICT sample includes the received responses from projects ended in 2000. In biotechnology, the history data is collected from those companies that were included in the BIO data and who had projects accepted for Tekes funding in 1997-1999.

4.2 Description of the samples

The whole data included 293 companies. Out of the two sub samples the ICT group is the largest comprising 240 companies (81.9%). The biotech sample size is 53 companies (18.1%). The sample of biotech companies is bit smaller than for example in the recent research published by ETLA (N=84) (Hermans, 2004a). From the ETLA database Raine Hermans' study focuses on pharmaceutical companies and companies whose customers are or will be pharmaceuticals (N=42) and to the explanation of their business potential as companies. According to ETLA studies there are approximately 140 companies in biotechnology in Finland and in ICT 4000-5000 (Luukkonen, 2004b). 140 companies in biotechnology include also large companies. In this respect the SME biotech sample in this study is quite representative, since some of the 140 are also inactive due to various reasons e.g. they are established in order to safe-guard accepted patents or they have not been able to raise sufficiently money for starting business. As the focus of this study is not a company level, the samples consists more cases than there is companies. In biotech many companies have applied funding for different projects and this is the reason for higher total sample (80 projects for 53 firms). The ICT sample is a smaller set compared to the whole population, but for statistical purposes it has enough power. In fact the sample could be overly sensitive but in the regressions from the data only 206 cases are included listwise due to missing data problems. In biotech the number of projects accepted listwise in the regressions is 65-70 (depending on the regression model used) out of 80 projects included in the data. The ICT companies had usually only one project during the period. The sample period for biotech companies is half a year longer than for ICT sample which could explain at least partly the higher number of projects per company in BIO data. At this point it is worth noting that the projects included are all project applications from the sample periods i.e. also rejected projects are included in order to at least partly avoid the obvious selection bias problem in the samples.

In the next table (Table 4) is gathered the key descriptive statistics analyzed in the following pages. The company distribution by region in Table 4 reflects relatively well the overall geographical distribution of biotech companies in Finland (Luukkonen, 2004a). Finland Proper (17 companies) and in it especially Turku (15) has a major share alongside with Uusimaa (16). Far behind come Northern Savonia (6), Northern Ostrobothnia (5) and Pirkanmaa (4). Compared to the overall distribution presented by Luukkonen, it seems that Uusimaa is underrepresented in this data. In Luukkonen's description out of the 140 companies 47 comes from Helsinki and only 38 from Turku region.

Table 4.

The description of the sample

The table show few key descriptive statistics of the data. The number of firms, projects, distribution by region, age structure, company size, and the existence of venture capitalist lays the foundation of the study. R&D intensity, company solidity, export intensity, turnover and earnings before interest and taxes in 2001 and 2002 give a portrait of the financial status of the companies.

	BIO	ICT	ALL DATA
Number of firms	53	240	293
Number of projects	80	256	336

Distribution by region

South Karelia	0.0%	1.7%	1.4%
Southern Ostrobothnia	3.8%	0.8%	1.4%
Southern Savonia	0.0%	0.8%	0.7%
Tavastia Proper	3.8%	0.4%	1.0%
Eastern Uusimaa	0.0%	0.4%	0.3%
Kainuu	0.0%	0.8%	0.7%
Central Ostrobothnia	0.0%	0.4%	0.3%
Central Finland	1.9%	2.9%	2.7%
Lapland	0.0%	0.4%	0.3%
Pirkanmaa	7.5%	7.1%	7.2%
Ostrobothnia	0.0%	0.8%	0.7%
North Karelia	0.0%	1.3%	1.0%
Northern Ostrobothnia	9.4%	14.6%	13.7%
Northern Savonia	11.3%	2.9%	4.4%
Päijänne Tavastia	0.0%	2.1%	1.7%
Satakunta	0.0%	2.9%	2.4%
Uusimaa	30.2%	55.4%	50.9%
Finland Proper	32.1%	4.2%	9.2%
Age Structure			
0-4	37.7%	50.4%	48.1%
5-8	32.1%	16.7%	19.5%
9-24	28.3%	30.8%	30.4%
>=25	1.9%	2.1%	2.0%
Company size			
0-4	45.3%	29.2%	32.1%
5-9	13.2%	23.3%	21.5%
10-19	17.0%	20.8%	20.1%
20-49	17.0%	20.0%	19.5%
50-249	7.5%	6.3%	6.5%
250-499	0.0%	0.4%	0.3%
Venture capitalist			
No venture capitalist	39.6%	65.0%	60.4%
Venture capitalist	60.4%	35.0%	39.6%

2002	BIO	N	ICT	N	ALL DATA	N
Mean R&D intensity	68.9%	35	48.3%	187	51.6%	222
Median R&D intensity	15.5%	35	32.3%	187	32.3%	222
Mean solidity	51.8%	35	41.1%	197	42.7%	232
Median solidity	53.3%	35	43.8%	197	47.3%	232
Mean export	24.5%	35	16.3%	189	17.6%	224

intensity						
Median export intensity	0.0%	35	0.0%	189	0.0%	224
Mean turnover, €	559,432	39	1,595,818	198	1,425,274	237
Median turnover,€	70,000	39	326,000	198	303,000	237
Mean earnings,€	-1,745,402	36	-480,981	198	-675,508	234
Median earnings,€	-107,500	36	-21,000	198	-36,000	234

2001	**BIO**	**N**	**ICT**	**N**	**ALL DATA**	**N**
Mean R&D intensity	42.5%	45	48.2%	168	47.0%	213
Median R&D intensity	30.0%	45	25.7%	168	26.7%	213
Mean solidity	51.9%	45	39.9%	171	42.4%	216
Median solidity	66.0%	45	49.3%	171	52.7%	216
Mean export intensity	32.1%	33	18.5%	156	20.9%	189
Median export intensity	9.7%	33	0.0%	156	0.0%	189
Mean turnover, €	670,743	46	1,496,264	174	1,323,655	220
Median turnover,€	52,500	46	341,000	174	252,500	220
Mean earnings,€	-1,030,993	46	-396,105	173	-529,460	219
Median earnings,€	-35,000	46	-3000	173	-5000	219

The ICT sample is heavily Uusimaa driven; 133 companies out of 240 (55.4%) originates from Uusimaa; Helsinki (79) and Espoo (47) leading the way. Other notable regions are Northern Ostrobothnia (35), Pirkanmaa (17) and Finland Proper (10). From Northern Ostrobothnia the Oulu-region (27) is according to expectations well represented since it has strong ICT sector in general. Regions without projects are Kymenlaakso and Åland Islands. Åland Islands is an autonomous province of Finland and companies from this province are not eligible for funding from Tekes.

Biotech companies are relatively young in the sample. 37.7% are 0-4 years old and 32.1% 5-8 years old. Thus approximately 70% of the biotech companies are established 1996 or later. Only one company is more than 25 years old. Similar age structure is also in ICT companies; half of the companies are 0-4 years old. The major part of the companies being very young is partly explained by the boom in ICT in the late 90's and early 2000. However, it is also explained by the activities of Tekes in 2003. Tekes increased its funding for start-ups and young companies in 2003 in order to strengthen the growth of high-tech companies from the beginning.

Company size is also measured[11]. Biotech companies are small almost entirely. Only 4 companies (7.55%) are medium-sized companies. 45.3% of the companies had 4 or less employees. 75.5% of the companies employ less than 20 persons. In ICT the cumulative percentage for firms employing less than 20 persons is nearly the same but in general the distribution by size is more evenly distributed. Medium-sized companies are better represented in the ICT group.

Venture capital involvement is quite frequent in biotech companies since roughly 60% has VC investments. In the ICT sample 35% has venture capital. Biotech as a business is typically capital intensive and by default involves capital investments. Foreign VC involvement is also studied and in both groups it is quite marginal[12]. These results support the views that foreign VC is underrepresented in Finnish high-tech companies. Finnish VC's portfolio companies in all data are centred to Uusimaa (52.6%) before Finland Proper (12.9%) and Northern Ostrobothnia (10.3 %). Major part of the investors is in very young companies, 0-4 years (44%). From biotech companies Finland Proper has best caught the eye of VC's having 43.8% of investors. In ICT VCs are strongly concentrated in Uusimaa (60.7%), the second being Northern Ostrobothnia with 11.9% of investors.

Both samples have very R&D-intensive firms[13]. The mean R&D-intensity in 2001 for biotech firms is 42.5% and for ICT firms 48.3%. In 2002 the mean R&D-intensity for biotech firms is as high as 69.0% and for ICT 48.3%. Especially the results for year 2002 are somewhat expected because some of the biotech firms have extremely high R&D-costs resulting to higher mean figure. The median intensity is nearly the same for both groups in 2001. In 2002 the median is higher for ICT companies.

---

[11] Small company = less than 50 employees. Medium-sized company = less than 250 employees.

[12] The percentage share of foreign venture capital investments from the ALL DATA is 5-7 %. However, there might be some measurement error due to problems of defining foreign VC. In spite of that I believe that the level is right.

[13] R&D-intensity = R&D costs in 2002 or 2001 divided by the balance sheet of that year.

The solidity of biotech firms for example in 2002 (mean 51.9%) is higher than in ICT (39.9%) firms. This reflects the fact that in biotech firms VC's are more actively engaged. Also in general biotech firms cannot raise traditional loans from banks due to lack of collaterals. However, these results indicate also that strong solidity is needed in ICT. In some cases it also means that company has been profitable and the balance sheet is stronger due to accumulated earnings.

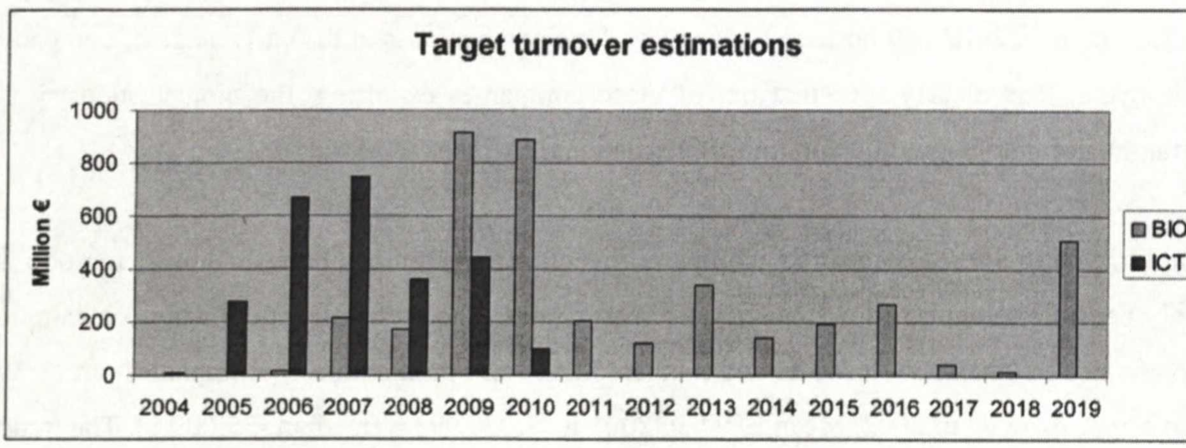
Export intensity is highest in the biotech sample in both years. However, the median value for both groups in 2002 is 0 because major part of the companies is in the early stage of company life cycle. It is clearly seen that out of those companies exporting, the biotech industry is straight from the beginning aiming for international markets.

Due to young age of companies, company revenues and earnings data for longer periods is only possible to achieve for smaller set of companies. The mean revenue for biotech sample companies in 2001 is 670,743 €, and median 52,500 €. For example 14 companies out of 39 have zero revenue in 2002. Mean EBIT in 2001 is -1,030,993 € (median -35,000 €). The trend of higher burn rates of some biotech companies is seen from the EBIT values through years 1999-2002. The mean revenue for ICT group companies in 2001 is 1,496,264 € (median 341,000 €) and mean EBIT -396,105 € (median -3000 €). This simple description shows that ICT companies are clearly in the business but are unprofitable. One reason for making losses is probably their high R&D-intensity showed earlier. In both groups companies are young and in their early phase of development and in the same time developing their product portfolios through R&D. The median and mean turnover figures are higher in 1999 than they are in the last two years. A decreasing trend is noticeable in the mean and median figures of earnings before interest and taxes from 1999 onwards which would at least partly reflect the overall trend in the ICT before and after the Internet bubble without forgetting the overall economic downturn in Finland.

The data for project-based target turnover estimations include 350 projects for 293 companies. Turnover estimations of 14 projects are not available because the nature of the projects did not allow turnover estimations for different reasons. 336 projects with turnover estimations include 256 ICT-projects and 80 biotech projects. The mean target turnover estimation for biotech projects is 51 million euros compared to 10 million euros for ICT projects. 5% trimmed mean for biotech is 31 million euros and for ICT 6,1 million euros.

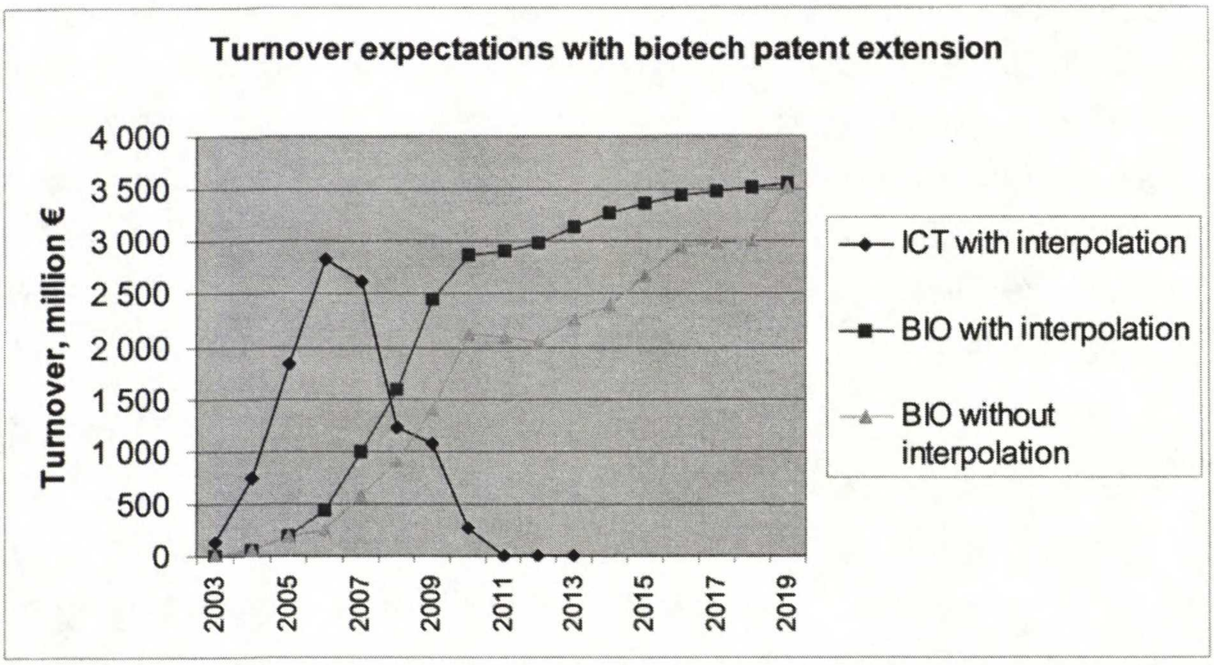
Median figures are little lower – 10 million euros for biotech and 3 million euros for ICT. Some ICT and biotech companies have very high turnover estimations reflected in the mean figures. Target estimations reflect also the difference between ICT and biotech expectation environment. The difference comes even clearer when comparing the turnover target years presented in Figure 7. The target turnover revenues for the bio companies are much further away than the estimates of the ICT companies.

Figure 7.



The data included also turnover estimations for market entry plus two subsequent years followed by the target year. In the Figure 8 the turnover figures for the years between market entry years and target year have been interpolated linearly. For biotech projects also turnover estimations without interpolation is shown in order to show a view where the time span between market entry years and target year is not expected to yield sales. Patent protection after target year has been supposed to last until the end of our research period for biotech enterprises.

Figure 8.



In the figure is described the turnover expectations of ICT and BIO firms with different scenarios. Interpolation means in this context that years between market entry and the target year are interpolated linearly. For BIO data also turnover estimations without interpolation is included to show a view where the time span between market entry years and target year is not expected to yield sales. For BIO enterprises patent protection after target year is supposed to last until the end of our research period.

It is easily seen how different the projects are when timing and level of expected sales is considered. The biotech projects are supposed to yield significant sales after 2007 and the first peak should be in 2010 with interpolation. Even without interpolation the sales in 2007 would be above 500 million euros and the first peak would be in 2010. After 2010 there will be also target years with significant sales leading to 3,5 billion sales in 2019 all projects included. The sales peak for ICT companies is already in 2006, which reflects the product development period of two to three years in software development. For ICT projects no sales extension period after target year is extrapolated because product life cycle is quite short in ICT. This is why the target turnover graph decreases so drastically after the target year for ICT companies. Generally, it is very likely that no failure probabilities have been considered from company side because the turnover levels are so high. It is clear that many projects will not succeed.

The failure probabilities of projects would be interesting to study. By determining the failure rate of the projects it would be possible to create a more reasonable picture of the projects.

Most common market entry year for a biotech company project is 2004 and 2005. The market entries normally mean licensing fees and milestone payments. In many cases the target year revenue estimation is not direct sales revenues but royalties from another company which is expected to take the company R&D-product to the markets. The most common target year for biotech projects is 2010 (27.5%). For ICT projects the most common market entry years are 2003 and 2004. The most common target year is 2006 (37.8%) followed by 2007 (22.0%) and 2005 (21.2%)

4.3 Expert interviews

To gain qualitative information on company revenue estimations, I discuss the results with Tekes experts of ICT and biotechnology. The primary goal is to achieve in-depth knowledge of the dynamics behind company growth estimations. The objective is to gain understanding of the interactions behind the data but also to get deeper understanding of the findings and also to challenge them against industry expert's views. Expert interviews are not written out in the study as an independent chapter. The primary goal of the discussions is to contemplate and refine the analysis.

4.4 The market analyses behind the growth estimations – a qualitative approach

Another attempt to get behind the figures is done by analyzing the qualitative information provided by the companies themselves when applying funding from Tekes. The most important part is the applicants' analyses of the business potential of the project. The information received from the applications is viewed against the turnover estimations given by the companies. Similarly to expert interviews, the results of the qualitative approach are used in the study only to contemplate and refine the analysis not as an independent part of the study itself. Limited space and the focus of the study affected also how the interviews and the qualitative part were arranged.

4.5 Measures for testing hypotheses

In the following sections I will present the variables, the dependent variable and several independent and control variables. The regression tests are introduced in Chapter 4.6.

4.5.1 Estimated target turnover

In the Chapters 3.5-3.10 systematic factors behind company growth has been discussed. There is many ways to determine company growth. Turnover development is often used measure. In this study, the focus is more specific. Instead of aggregate company turnover figures, the measure is project-specific turnover growth estimates. The dependent variable is the estimated target turnover for a R&D project (summary statistics in Table 5). Companies have estimated themselves a target turnover for their R&D project when applying funding from Tekes. The basic idea of the regression is to find relevant factors behind company growth estimations.

Table 5.

Summary Statistics of Target Turnover for Model 1 and Model 2

The table presents the means (Mean) and standard errors (Std. error) for the dependent variable target turnover. Target turnover is the estimated turnover of a R&D project. Summaries of a target turnover in both models have been included in the table.

Model 1		**Mean**	**Std. error**	**N**
BIO	Target turnover	54,427,941.08	16,181,965.53	65
ICT	Target turnover	9,292,072.33	1,467,364.35	206
ALL DATA	Target turnover	20,118,018.71	4,184,008.02	271
Model 2				
BIO	Target turnover	47,110,916.71	13,644,859.89	70
ICT	Target turnover	9,495,883.01	1,469,656.79	206
ALL DATA	Target turnover	19,035,927.79	3,744,816.62	276

The following variables have been formed based on earlier scientific research dealt in Chapter 3.

4.5.2 Independent and control variables

The study included various independent variables to explain target turnover figures. The regression models include 5-6 independent variables depending on the model and one control variable. The summary statistics of the variables are presented in the Tables 6-7.

R&D intensity and R&D costs

Company R&D investments relative to company balance (R&D intensity) is considered as an input factor behind company growth. Normally the intensity is measured by dividing the reported yearly R&D costs by total costs. The data did not include total costs of companies. The balance of a company is a closest proxy at hand. In the section 4.5 I will present the regression models but it is worth noting also here that two models were formed from the data. The first model used proportional data like R&D-intensity and the second was formed from absolute figures. Thus, in the other model yearly R&D costs were regressed against target turnover. R&D costs are from years 2001 or 2002 depending on the availability of information. The majority of the data was from year 2002.

Solidity

The inverse relation between leverage and high tech company growth with risky projects is quite generally accepted concept. Solidity is measured by dividing capital and reserves by balance sheet. The figures are also in this case mainly from 2002 but in some cases date back to financial statements of 2001. Solidity is used as an independent variable only in the model with proportional variables.

Table 6.

Summary statistics of the Independent and Control Variables in Model 1

The table show the means (Means) and standard error (Std error) for the independent and control variables. Solidity = capital and reserves / balance sheet; Export intensity = exports / turnover; Venture capitalist = whether the company has venture capitalist involved (0 = no, 1= yes); Future R&D investments related to company balance = Project related future R&D investment / balance sheet; Hot market condition = revenue increase 1999-2002 or in case of no data from that period – longest period possible; Company age = age of company in year 2004; R&D intensity = yearly reported R&D costs / balance sheet.

		Mean	Std error	N
BIO				
	Solidity	51.19	3.05	65
	Export intensity	21.33	4.33	65
	Venture capitalist	0.74	0.05	65
	Future R&D investments related to company balance	37.80	36.30	65
	Hot market condition	209,963.08	67,374.98	65
	Company age	8.32	0.59	65
	R&D intensity	88.45	10.64	65
ICT				
	Solidity	40.91	3.44	206
	Export intensity	17.32	2.11	206
	Venture capitalist	0.41	0.03	206
	Future R&D investments related to company balance	3.95	1.11	206
	Hot market condition	701,482.52	161,256.96	206
	Company age	8.29	0.41	206
	R&D intensity	48.22	3.77	206
ALL DATA	Solidity	43.38	2.72	271
	Export intensity	18.28	1.91	271
	Venture capitalist	0.49	0.03	271
	Future R&D investments related to company balance	12.07	8.74	271
	Hot market condition	583,590.41	124,214.71	271
	Company age	8.30	0.34	271
	R&D intensity	57.87	3.97	271

Export intensity and exports

Finland is a small player in a world scale and like Virtanen (1996) is his study has concluded, the growth opportunities in Finland many times are based on international activity i.e. exports. Exports are used in the regressions both proportionally and in absolute figures.

Future project R&D investments related to company balance and future project R&D investments

If earlier R&D investments were considered as growth factors, it would be natural to suggest that also future R&D money is relevant especially when future growth is considered. It could be also argued that past R&D investments are not as effective measure since it is a sunk cost and perhaps in some cases in ICT already realized commercially. Earlier R&D is also in many cases formed from different projects and is perhaps not as effective as the R&D investment which is directly aimed at to realize the project-specific potential at the target year. The independent variable is formed by dividing the future R&D investment of the project by company balance. In the second regression the R&D investment is used as such to explain the growth potential.

Table 7.

Summary statistics of the Independent and Control Variables in Model 2

The table shows the means (Means) and standard error (Std error) for the independent and control variables. Exports = yearly exports; Venture capitalist = whether the company has venture capitalist involved (0 = no, 1= yes); Future R&D investments = Project related future R&D investment; Hot market condition = revenue increase 1999-2002 or in case of no data from that period: longest period possible; Company age = age of company in year 2004; R&D costs = yearly reported R&D costs.

		Mean	Std. error	N
BIO				
	Exports	291,028.57	109,004.29	70
	Venture capitalist	0.73	0.05	70
	Future R&D investments	1,882,426.67	375,376.10	70
	Hot market condition	235,827.14	70,128.92	70
	Company age	8.04	0.56	70
	R&D costs	2,525,157.14	453,075.60	70
ICT				
	Exports	619,514.56	140,212.90	206
	Venture capitalist	0.41	0.03	206
	Future R&D investments	603,274.14	58,793.02	206
	Hot market condition	706,122.82	161,212.96	206
	Company age	8.38	0.42	206
	R&D costs	750,252.43	13,832.45	206
ALL DATA				
	Exports	536,202.90	108,484.27	276
	Venture capitalist	0.49	0.03	276
	Future R&D investments	927,696.88	109,619.18	276
	Hot market condition	586,844.93	122,170.29	276
	Company age	8.29	0.35	276
	R&D costs	1,200,409.42	192,774.35	276

Hot market condition

The hot market condition variable is formulated in order to see whether earlier development of company's businesses have effect on their views of future prospects. The variable is formed by deducting from 2002 sales the sales from 1999. In case the company is formed later on, or the data is incomplete for some other reason, the period under examination is the longest possible between 1999-2002. The actual revenue increase is thus expected to be higher for companies with high future growth prospects. Special group to be studied are gazelle companies i.e. the company revenue has increased 20% or more per year for three years (2000, 2001, 2002) and the starting level of sales has been at least 100,000 €. If the company fulfilled the criteria it was assigned the value of 1, if not the dummy variable was 0.

Venture capitalist

This control variable is formed to find out the possible "turbo effect" of venture capitalists mentioned earlier. Venture capitalist control variable is a dummy variable that is assigned the value 0, when company do not have venture finance, and the value 1, when the company has a venture finance investment. The information is gathered from the project appraisal memorandums of Tekes. The information is semi-structured, and it had to be in some cases completed from other sources like Suomen Asiakastieto Oy.

Company Age

The last independent variable used is company age. Like in the chapter 3.10 was mentioned young Finnish biotech firms anticipate to grow faster than the old ones. This study will try to verify it by utilizing age as an independent variable. The same variable will be used also in the ICT data to see whether similar situation is in effect also there

The independent variables in the two models are not highly correlated. Table 8 and Table 9 below shows correlations between independent variables used in the two models.

Table 8.

Correlations of the Independent and Control Variables in Model 1

The table indicates the correlation between the independent and control variables in Model 1. Correlations with statistical significance are marked with an asterisk: ** (p<0.01), * (p<0.05). The definitions of variables are explained in Chapter 4.5.2.

		1	2	3	4	5	6
BIO	1 Solidity						
	2 Export intensity	-0.25*					
	3 Venture capitalist	0.21	-0.22				
	4 Future R&D investments related to company balance	0.17	-0.07	-0.21			
	5 Hot market condition	-0.10	0.21	-0.16	-0.04		
	6 Company age	-0.23*	0.26*	-0.17	-0.07	0.35**	
	7 R&D intensity	-0.20	0.12	0.33**	-0.13	-0.23*	-0.01
		1	**2**	**3**	**4**	**5**	**6**
ICT	1 Solidity						
	2 Export intensity	0.10					
	3 Venture capitalist	0.08	0.16*				
	4 Future R&D investments related to company balance	0.05	-0.05	-0.05			
	5 Hot market condition	0.12	0.15*	0.28**	-0.07		
	6 Company age	-0.01	0.13*	0.00	-0.13	0.13	
	7 R&D intensity	-0.22**	0.08	0.17*	0.01	-0.06	-0.25**
		1	**2**	**3**	**4**	**5**	**6**
ALL DATA	1 Solidity						
	2 Export intensity	0.05					
	3 Venture capitalist	0.12	0.07				
	4 Future R&D investments related to company balance	0.06	-0.04	-0.07			
	5 Hot market condition	0.10	0.14	0.19**	-0.02		
	6 Company age	-0.04	0.16**	-0.03	-0.04	0.14*	
	7 R&D intensity	-0.16**	0.11	0.27**	-0.05	-0.09	-0.18**

In the first model the independent variables is mostly constructed so that the size factor of a firm is controlled. The correlations are not high in the two sub samples or in the whole data. This would indicate that multicollinearity is not a significant problem in this model. The correlations are intuitively logical. For example in the biotech data the negative correlation between company age and solidity would suggest that young biotech companies have higher solidity. Young biotech firms are heavily financed by outside equity. It is not surprising that hot market condition and company age have a significant positive correlation since it is quite clear that only older firms have established they presence in a way that they have increased they revenues in 1999-2002. In many younger biotech firms the revenues are very modest. ICT firms have inverse relation of R&D intensity with solidity and company age. It is possible that the first correlation is due to the fact that in the sample ICT firms have less VC investors involved and this could be a reason for the inverse relation of solidity and R&D intensity. The higher the R&D intensity the weaker the solidity if losses are not channelled to deferred charges and the firm is otherwise from a business point of view in a R&D phase. Also, older companies have normally smaller R&D intensity than the younger ones since they have also other expenses. Other intuitively correct correlation in the ICT data is the positive correlation between company age and exports. The correlations of venture capitalists are in the tables not directly interpretable since it is a dummy variable. Naturally, it gives an idea of the direction of the relation but nothing more.

Table 9.

Correlations of the Independent and Control Variables in Model 2

The table indicates the correlation between the independent and control variables in Model 2. Correlations with statistical significance are marked with an asterisk: ** (p<0.01), * (p<0.05). The definitions of variables are explained in Chapter 4.5.2.

		1	2	3	4	5
BIO	1 Exports					
	2 Venture capitalist	-0.30**				
	3 Future R&D investments	-0.11	0.21			
	4 Hot market condition	0.74**	-0.16	-0.09		
	5 Company age	0.20	-0.17	-0.06	0.35**	
	6 R&D costs	-0.10	0.34**	0.39**	-0.05	-0.08
		1	**2**	**3**	**4**	**5**
ICT	1 Exports					
	2 Venture capitalist	0.18**				
	3 Future R&D investments	0.44**	0.24**			
	4 Hot market condition	0.51**	0.28**	0.18**		
	5 Company age	0.31**	0.00	0.05	0.13	
	6 R&D costs	0.34**	0.23**	0.34**	0.56**	0.01
		1	**2**	**3**	**4**	**5**
ALL DATA						
	1 Exports					
	2 Venture capitalist	0.09				
	3 Future R&D investments	0.11	0.25**			

4 Hot market condition	0.52**	0.19**	0.02		
5 Company age	0.30**	-0.03	0.00	0.14*	
6 R&D costs	0.22**	0.31**	0.39**	0.38**	-0.02

In the second model (Table 9) the correlations are higher but still in a reasonable level when multicollinearity is considered. The second model gives other interesting correlations. Firms with high past R&D investments will continue to invest in R&D more than other companies in all samples. Hot market condition and exports are in all samples highly correlated. This indicates that companies with higher actual revenue increase have also higher exports. This is even clearer in the biotech where the correlation is the highest (0.74) – companies are international already from the start. Cautious interpretation of the relation between venture capitalist and the other variables in the Model 2 would be that there seem to be to a certain extent a relation between hot market condition and the involvement of a venture capitalist in ICT data. In the Model 1 there was also a positive relation between a VC and exports. Interest of a venture capitalist on firms with higher revenue increase and higher export share is very likely.

4.6 The econometric models

In the next sections the regression models for testing the target turnover hypothesis is presented.

4.6.1 Model 1: Test of proportional variables on target turnover

The hypothesis H1-H7 described earlier (see Ch. 3.5-3.10) will be tested by regressing 6 independent variables and one control variable against the target turnover (see Ch 4.4.1). The regression model used is a linear regression:

$$Y_{TARGET\ TURNOVER} = b_0 + \sum_{i=1}^{n=6} b_i * X_i + b_7 * C_1 + \varepsilon \qquad (1)$$

including independent variables X_1 to X_6 and the control variables C_1:

X_1 = Solidity;

X_2 = Export intensity;

X_3 = Future R&D investments related to company balance;

X_4 = Hot market condition;

X_5 = Company age;

X_6 = R&D intensity;

C_1 = Venture capitalist

The sample sizes are following: BIO (N=65), ICT (N=206) and ALL DATA (N=271).

4.5.2 Model 2: Test of variables without proportionality on target turnover

The second model is a linear regression where R&D costs, exports and future R&D investments are not divided by a company size measure. Five independent and one control variables is regressed against the same dependent variable i.e. the target turnover.

$$Y_{TARGET\ TURNOVER} = b_0 + \sum_{i=1}^{n=5} b_i * X_i + b_6 * C_1 + \varepsilon \qquad (2)$$

including the independent variables X_1 to X_5 and the control variable C_1:

X_1 = Exports;

X_2 = Future R&D investments;

X_3 = Hot market condition;

X_4 = Company age;

X_5 = R&D costs;

C1 = Venture capitalist

The sample sizes for the second model are: BIO (N=70), ICT (N=206) and ALL DATA (276). The sample sizes are smaller than the total sample presented in the Chapter 4.2 because cases were included list wise according to complete case approach. Both regressions are performed for BIO, ICT and ALL DATA. The results from the models are presented in the Chapter 5.

4.7 Limitations of the study

The sample size and the sample issues were dealt in the sample description part (see Ch. 4.2). However, the selection bias issues need to be discussed. When interpreting the results one has to take into the consideration the possibility that the companies especially in the ICT sample do not represent the whole ICT population. The biotech sample represents quite well the whole population of active companies. The selection period of ICT data (year 2003) is short and there could be reasons why certain type of companies have applied funding in a certain year e.g. Tekes might have a focused technology program going on and certain type of companies might be interested to apply when the topic matches their interest. It is also possible that companies with only the most risky projects apply funding. This is actually also very likely since Tekes specifically shares technology risk by partly funding the projects. This also means that the risk and the return should be related and thereby target turnovers should be also high. However, high tech companies in general are in the forefront of the development and the way to stay in the frontline is the risk-taking attitude. In that respect I believe that the companies in the sample represent quite well the Finnish high tech companies.

Earlier I also mentioned that in 2003 Tekes funding for start up companies increased significantly compared to previous years (Tekes, 2003). This means that many of the companies did not have e.g. their first financial statements ready at the time of applying funding. In some cases the previous year's financial statement was not ready at the time of applying funding reducing the cases included in the regressions. This caused a deviation between the projects described in the description part and the projects included in the regressions. However, I made a careful missing data analyses where I did not find any other systematic reason for missing data than those mentioned above. Naturally the number of companies is smaller in the regression, but there is no reason to believe that it deviates significantly from the total sample. Evidence for similar conclusion is possible to derive also from the regression results.

Measurement error is not a problem since the project specific turnover as a dependent variable is valid. Of course there is a possibility that the experts in Tekes could have changed for example the target years or the turnover level based on their expertise but it is quite rare based on my own experience. Tekes has also its own classification[14] for target turnovers. I included all the target turnover estimations regardless of the classification. In my opinion the classification is not needed here since the level of estimated target turnover is only relevant. In any case the absolute majority of the cases are in one of the three classes making the classification problem quite marginal.

A specification problem is possible because the consideration of independent variables was constrained by the data available. For example patents would have been interesting to include in the models but it was not possible to systematically sort out accepted patents. However, almost all biotech companies had accepted patents or patents pending and it would probably not have changed the results obtained. In ICT the patent strategy is different and not always as vital as in biotechnology. Other specification problem was the definition of venture capitalist. The classification of a venture capitalist was made based on the project appraisal memorandums. A venture capitalist was defined to belong to the members of Finnish Venture Capital Association. However, also other companies investing in the spirit of FVCA were included based on my own judgement because it is possible that not all are members. Hot market condition was applied also slightly differently than originally planned. Since so many companies were formed after 1999 I decided to include the actual revenue increase also from the shorter period, which in my opinion is justified because revenue increase or decrease from a shorter period could also influence the future estimates of the companies. Gazelle examination was made partly redundant the fact that so many companies were young and in biotechnology only rare companies had revenue in the first place. I found 12 gazelles, nine

[14] Tekes has a three stage classification for target turnover: 1. The funded project will create new turnover, 2. The funded project will lead partly to the renewal of company turnover but is not completely new, 3. The project does not increase company turnover.

from ICT and three from BIO sample. The result was somewhat expected since the companies were in many cases in the early phase of their development. More data would have been needed to validate the use of a gazelle dummy variable.

In the data processing phase I also checked that the projects were not continuations of the same project funded earlier in the study period. This was major concern only in biotechnology were projects are often funded in periods.

The normality of the variables included was studied. Variables did not correspond to the normal distribution but the number of observations in all three samples was high enough for statistical testing. Heteroscedasticity was an evident problem since as target year is further away, there is a wider range of possible target turnover values which leads to a non constant variance of the error term. The problem was most concrete in biotech firms. I tried one of the variance-stabilizing transformations (logarithms) but the data included so many zero values and even negative values (solidity) that the sample would have shrunk in size. Heteroscedasticity is related to the interpretation of the results and will be taken into the consideration when results are evaluated. Another interesting dilemma was the dependence of the residuals in the regression on the dependent variable. One obvious cause is the heteroscedasticity problem which I could not remedy but another reason is a possible absence of a relevant variable in the model. The relation decreased when I added the last variable in the models which proved to be the most significant one. The dependency of the error term was however still statistically significant especially in the ICT sample.

Table 10.

The dependency of the error term with the dependent variable in Model 1-2

In the table it is easily seen the heteroscedasticity problem due to high correlations. Another reason is that the model might lack significant independent variables. Both problems are very common in regression analyses and influence negatively the conclusions made from the study. Significant correlations are marked with asterisk: ** (p<0.01).

Model 1		**Target turnover**
Standardized Residual BIO	Pearson Correlation	0.59**
	Sig. (2-tailed)	0.000
	N	271
Standardized Residual ICT	Pearson Correlation	0.86**
	Sig. (2-tailed)	0.000
	N	271
Standardized Residual ALL DATA	Pearson Correlation	0.93**
	Sig. (2-tailed)	0.000
	N	271
Model 2		
Standardized Residual BIO	Pearson Correlation	0.48**
	Sig. (2-tailed)	0.000
	N	276
Standardized Residual ICT	Pearson Correlation	0.91**
	N	276
Standardized Residual ALL DATA	Pearson Correlation	0.59**
	Sig. (2-tailed)	0.000
	N	276

One of the most important issues before interpreting the results is to assess the correlation between the independent variables. Ideally the regression model should have high correlation between the independent and dependent variable and in the same time very small correlation between independent variables themselves (Hair et al., 1998). If high correlation between the independent variables does exist i.e. multicollinearity is affecting the results, certain remedies are needed because one consequence is the difficulty to determine the contribution of each variable due to mixed influence of the variables. In the earlier section (4.4.2) correlations between the independent variables were examined. In the both models correlations were not very high. Thus multicollinearity should not be a significant problem in the analysis. In addition to a simple correlation analysis, each independent variable is regressed on each other. In the following table is calculated the two common measures for assessing the multiple variable collinearity. The tolerance value and its inverse the variance inflation factor (VIF) indicate the degree to which each independent variable is explained by the other independent variables. Tolerance is the variability of the selected variable not explained by the other independent variables. Very small tolerance values and very high VIF values indicate high collinearity. According to Hair et al. (1998) a common threshold is a VIF value above 10 which corresponds to a tolerance value of 0.10.

Table 11.

Multicollinearity of the Independent Variables

The table show the tolerance value and the variance inflation factor (VIF) for Model 1 and 2. The tolerance value below 0.10 and the VIF value above 10 are considered as normal thresholds when assessing multicollinearity (Hair et al., 1998).

Model 1	**BIO**		**ICT**		**ALL DATA**	
Variable	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF
Solidity	0.82	1.22	0.91	1.10	0.93	1.07
Export intensity	0.86	1.16	0.89	1.12	0.92	1.09
Venture capitalist	0.73	1.36	0.85	1.17	0.85	1.18
Future R&D investments related to company balance	0.88	1.13	0.97	1.03	0.99	1.02
Hot market condition	0.81	1.24	0.89	1.12	0.92	1.09
Company age	0.76	1.32	0.84	1.19	0.88	1.13
R&D intensity	0.76	1.32	0.84	1.19	0.84	1.19

Model 2	**BIO**		**ICT**		**ALL DATA**	
Variable	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF
Exports	0.42	2.40	0.56	1.80	0.67	1.49
Venture capitalist	0.73	1.38	0.87	1.15	0.84	1.19
Future R&D investments	0.86	1.16	0.70	1.42	0.82	1.22
Hot market condition	0.41	2.43	0.50	1.99	0.61	1.64
Company age	0.85	1.18	0.86	1.17	0.88	1.14
R&D costs	0.83	1.21	0.58	1.72	0.69	1.44

The last methodological problem discussed here is the possible effect of outliers. Especially in the biotech group very high target estimations concentrated on few companies i.e. pharmaceutical companies. These companies have very high expectations of their projects based on various reasons not least for the reasons of international markets and the price setting possibility due to patent rights. These unique projects are quite distinct with a lot of risky involved. However, the inclusion or exclusion of projects should be based on the information these unique projects can deliver, many times they could be the most interesting ones in the research. Pharmaceutical projects represent the outer limit of target turnover landscape and needs to be included in the data set. In spite of this I will come to this problem in the next section when the findings are reviewed because they can seriously distort the statistical tests.

5. Findings

In this chapter I will present the results of the regression models and discuss the possible reasons and the significance of the findings. The impact of venture capitalist (H1), exports and export intensity (H2), solidity (H3), past R&D costs and R&D intensity (H4), hot market condition (H5), future R&D investments and future R&D intensity (H6), and company age (H7) are explained in the context of company growth estimations. The results of the two models, Model 1 and Model 2, will be presented and the differences between the results considered. Next, the results are viewed in a retrospective way. For both industries I will present history data from earlier projects and how the project estimations have succeeded. The companies used in the biotech group are all companies from the regression models that had projects accepted for funding in 1997-1999. The past estimations of the project target turnover are compared to the resulted total turnover of the companies. For ICT group a similar type of setting is not possible but I will present another sample of ICT companies' growth estimations from the past where the companies have been asked to review later on how the estimations have realized and what will be the outcome in the future. To be clear, the ICT sample companies are different companies than used in the regression model. There is no comparison possibility, but it should give an idea of the risk incorporated in the projects. Finally I will review the follow-up memorandums of the ICT projects to understand the reasoning behind the development. In the end of the chapter 5 the industry sector differences are discussed.

5.1 The results of the test of proportional variables on target turnover (Model 1)

Table 12 presents the results of the Model 1. The overall fit of the first model is relatively low. The use of proportional variables does not explain much of the amount of variance. The adjusted R^2 for ALL DATA is 11%, 8.7% for BIO and 16.6% for ICT. The comparison of R^2 and adjusted R^2 reveals (adjusted $R^2 < R^{2)}$ that in all samples also insignificant variables are included in the regression models. The confirmatory approach used usually ends up in an above mentioned situation. However, the exclusion of the less powerful variables does not significantly improve the results i.e. the stepwise regression approach is not effective either. Statistically significant regression coefficients are in ALL DATA export intensity, R&D intensity, and venture capitalist. The expected sign of these variables is in accordance with the sign received. In BIO sample the whole regression according the ANOVA -test is insignificant (sig. 0.092), the ALL DATA and ICT sample regression tests are significant according to ANOVA results. The ICT sample provides few statistically significant variables. Exports, future R&D investment related to company balance and venture capitalist are statistically significant at 0.01 levels.

Table 12.

Test of proportional variables on target turnover (Model 1)

The table show the regression coefficients, beta coefficients (standardized), *t* value, R2, adjusted R2, and the standard error of the estimate. The variables are explained in the Chapter 4.5.2. Statistical significance marked with asterisk: ** (p < 0.01), * (p < 0.05).

Model 1

Model Component	**Exp. sign**	**ALL DATA**	**BIO**	**ICT**
intercept		-10,624,768	12,345,347	3,958,072
Independent variables				
X1 Solidity	+			
Regression coefficient		-4524	-690,489	-29,817
Beta coefficient		-0.003	-0.130	-0.700
t value		-0.049	-0.988	-1.046
X2 Export intensity	+			
Regression coefficient		288,053*	639,618	200,441**
Beta coefficient		0.132	0.171	0.289

t value		2.194	0.189	4.276
X3 Future R&D investments related to company balance				
Regression coefficient	+	26,568	46,169	265,749**
Beta coefficient		0.056	0.104	0.202
t value		0.959	0.815	3.116
X4 Hot market condition	+			
Regression coefficient		-0.663	16.362	0.813
Beta coefficient		-0.020	0.068	0.089
t value		-0.328	0.512	1.324
X5 Company age	-			
Regression coefficient		56,303	-2,292,028	-287,402
Beta coefficient		0.005	-0.830	-0.081
t value		0.075	-0.605	-1.158
X6 R&D intensity	+			
Regression coefficient		263,241**	380,775	16,254
Beta coefficient		0.250	0.250	0.042
t value		3.982	1.822	0.601
X7 Venture capitalist	+			
Regression coefficient		20,453,894*	59,589,715	7,416,545**
Beta coefficient		0.149	0.202	0.174
t value		0.018	1.451	2.517
R2		0.365	0.432	0.441
Adjusted R2		0.110	0.087	0.166
Standard error of the estimates		64,985,020	124,674,109	19,234,854
ANOVA -test		0.00**	0.92	0.00**

The standard error of the three sample regressions is quite high meaning that the quality and the accuracy of the Model 1 do not provide the highest level of assurance but on the other hand it could give interesting implications on explaining the reasons behind poor overall fit. The Model 1 is constructed so that the company size is controlled when explaining the estimates given by the companies. Based on the results obtained it seems that when controlling the size of the companies the regression do not give support for the high target turnover levels. The significant variables do implicate that especially R&D costs – past and future – are important factors in explaining and predicting high tech company growth. Export intensity and VC involvement are important factors behind ICT sample growth estimations like earlier scientific literature suggested. In other words the first hypothesis H1 venture capitalist is relevant like suggested (in ALL DATA and ICT), similarly the export intensity (H2) is relevant in ALL DATA and ICT. R&D intensity (H4) is relevant in ALL DATA and the future R&D investment related to company balance (H6) is important in ICT. Model 1 does not give evidence for the relevance of company age (H7), hot market condition (H5) and company solidity (H3). This does not mean that the variables would not be relevant in predicting the company turnover levels but in the model context they do not rise up. Discerning reader notice that in some variables, the sign of the regression coefficient changes between the sub-samples and the whole sample. This has minor effect on the results because the change of sign appears only when the variable is not statistically powerful.

The question that arises from the Model 1 is whether the target turnover estimates are realistic compared to the size of the company. The ALL DATA model explains only 11% of the amount of variance in the target figures. Later in this chapter I will return to this question of realistic turnover figures by using another set of data. It has to be kept in mind that these are just implications that have risen during the analysis and the statistical tests do not give the exact answer to these questions. The only way to plunge into the problem is a retrospective way done later on in this study.

5.2 The test of variables without proportionality on target turnover (Model 2)

The second model (Model 2) is constructed so that the company size control is released. This means that R&D costs, exports and future R&D investments are included as such in the regression. The reasoning behind is to test whether the results obtained from the first model would change now when the size of the company is not controlled. The results from the Model 2 are presented in the Table 13. The solidity factor is not included in the Model 2 but a test regression with solidity included reveals that it is not relevant factor in the Model 2 either. Solidity is not the only factor left in the shadows of more powerful predictors while the results of the second model turned to be very different from the first model.

The overall prediction accuracy of the second model is in ALL DATA 64.9%, in BIO 64.9 % and in the ICT 42.2%. The prediction accuracy is in a higher level that in the first model. The standard errors of the estimates decreased also substantially. In the chapter 4.6 I discussed also the relation of the error term with the dependent variable. There is a decrease in the dependency of the error term with the dependent variable in the ALL DATA and BIO in Model 2. While the dependency is still significant, the model 2 proved to include relevant factors for explaining target turnovers i.e. the release of company size factor improved the explaining capability of the Model 2. Obviously one of the reasons is that bigger companies have bigger turnover estimations. This is shortly tested empirically by adding another independent variable in the regression i.e. company balance as a proxy of company size. It showed that company size in these regressions is not statistically relevant factor. The reasoning behind this is that the turnover estimations are independent of the company size as shown next when the actual results of the Model 2 are discussed. In other words, in high tech world it is the future R&D investment that drives the expected turnover levels of SMEs and they are not dependent on the size of the company now as much as one could think. If large companies would be included the situation could change considerably since the target turnover levels are usually much higher. Target turnover levels being independent of company size raises naturally a question of the realistic level of the turnover estimations compared to the actual resources possessed by the companies. The same phenomenon is easily seen from the Table 6 in chapter 4.5.2 where the ratio of future R&D investments to company balance is enormous in BIO data (37.80) - almost forty times the size of the company. In ICT the same ratio is lower (3.95) due to lower level of investments needed to achieve R&D goals.

Table 13.

Test of variables without proportionality on target turnover (Model 2)

The table shows the regression coefficients, beta coefficients (standardized), *t* value, R2, adjusted R2, and the standard error of the estimate. The variables are explained in the Chapter 4.5.2. Statistical significance marked with asterisk: ** ($p < 0.01$), * ($p < 0.05$).

Model 2

Model Component	Exp. sign	ALL DATA	BIO	ICT
Intercept		-5,676,804	-10,812,792	806,943
Independent variables				
X2 Exports	+			
Regression coefficient		-2.482	-1.253	-0.033
Beta coefficient		-0.072	-0.010	-0.003
t value		-1.650	-0.091	-0.044
X3 Future R&D investments	+			
Regression coefficient		27,933**	29,537**	16,381**
Beta coefficient		0.818	0.813	0.655
t value		20.726	10.584	10.359
X4 Hot market condition	+			
Regression coefficient		0.809	1.901	1.157

Beta coefficient		0.026	0.010	0.127
t value		0.577	0.088	1.695
X5 Company age	-			
Regression coefficient		-60,826	330,786	-317,293
Beta coefficient		-0.006	0.014	-0.091
t value		-0.015	0.175	-1.588
X6 R&D costs	+			
Regression coefficient		-0.223	1.989	-1.299**
Beta coefficient		-0.011	0.066	-0.175
t value		-0.268	0.842	-2.521
X7 Venture capitalist	+			
Regression coefficient		869,676	-7,470,725	3,982,883
Beta coefficient		0.007	-0.029	0.093
t value		0.180	-0.350	1.638
R2		0.811	0.825	0.663
Adjusted R2		0.649	0.649	0.422
Standard error of the estimates		36,834,693	67,587,635	16,033,990
ANOVA -test		0.00**	0.00**	0.00**

When analyzing the results it is quite obvious that one variable is above the others when the statistical significance is considered. In every three samples the future R&D investment for the project in question is the best individual predictor in the model. It almost seems that it could solely explain the majority of the variations of the target turnover. In BIO sample the assumption is accurate while the regression with only one variable explains 64.4% (adjusted R^2) i.e. only 1.5 percentage units less than in the Model 2. In ICT future R&D investments could solely explain 23.7% compared to the adjusted R^2 of 42.2 % in Model 2.

The other variables included in the Model 2 thus are not as powerful as the future R&D investments variable alone is but they still have some additional explaining power on target turnovers. Other statistically relevant variables in the Model 2 are R&D costs in ICT. In ICT also control variable venture capitalist and hot market condition are close to have some statistical significance.

I tested also how the exclusion of unique project estimates[15] (17 projects) would show in the results and how the exclusion of some of the variables would change the situation. The majority of the excluded projects are from BIO data. The excluded variables are hot market condition and company age. In this reduced model the adjusted R2 is for ALL DATA 73.7%,

[15] unique project = error term in pairwise diagnostics was large.

for BIO 81.9% and for ICT 50.2%. The effect is naturally mostly seen in BIO data. The past R&D costs are now statistically significant in 0.01 level. In ALL DATA also exports become statistically relevant in 0.01 level. What this little test showed is that the statistical significance of a variable is dependent on these unique cases which nevertheless are not outliers in the traditional sense but they do have an influence on results.

The hypotheses put forward in the earlier sections 3.5 - 3.10 are discussed individually here for Model 2.

Venture capitalist (H1)

In the Model 2 the VC perspective is not statistically significant. Even the sign of the regression coefficient is mixed. The sign of the control variable in ALL DATA and in ICT is positive but negative in BIO. In a stepwise procedure I found a setting where VC is statistically significant in ICT in Model 2. The model included only future R&D investments, past R&D costs and exports in addition to VC control variable, i.e. the VC is effective variable only when the model 2 is more focused. The venture capital hypothesis is supported by the Model 1 in ICT.

Exports (H2)

The sign of the regression coefficient of exports is negative in Model 2. It is also negative in the reduced Model 2 where it is statistically significant. Quite many companies had zero exports and in many cases companies with the highest turnover estimates have not yet sales, not to mention exports. Another possible explanation is that companies with higher exports might concentrate more on the selling side than invest in R&D and thus have lower level of turnover estimates for R&D projects. The reason could be also in the model configurations and in the interrelations of the variables although multicollinearity is not considered as a problem. In the Model 1 export intensity is statistically significant in 0.01 level in ICT data and the sign is positive like expected.

Solidity (H3)

The solidity of the companies is in a good level in general (in both sub samples over 40%). In the regression the solidity variable does not raise above the other factors. In fact, it is not statistically significant at all in both models. This would indicate that there is no link between growth estimations and solidity. However, there is certainly a link between high tech firms and high solidity in general but high solidity seems to be unable to explain high turnover estimations in this study context.

R&D costs (H4)

The hypothesis 4 is that the larger the yearly R&D cost or R&D intensity before making the turnover estimations, the higher the targeted turnover. In Model 1 the R&D intensity is significant in 0.01 level and the sign is positive as expected in all three groups. In Model 2 pure R&D costs are significant only in ICT but the sign is negative. One factor influencing the model 2 results could be that in many cases the companies are in the early phase of their development and the absolute R&D costs are not yet as high as their target turnover estimates but in relation to their size the costs are significant as Model 1 suggests.

Hot market condition (H5)

Hot market condition is not statistically significant factor explaining companies project growth estimations in Model 1. In Model 2 it is statistically significant in 0.10 level (sig.0.092) in ICT sample, which is very interesting since the ICT data is the target data for this variable. The statistical significance is lower than the levels introduced for this study (0.01 – 0.05) but it is still worth noting. One reason which could influence the results of hot market condition is that the data does not include all the turnover figures for every company from 1999 onwards. The obvious reason is that companies are formed in many cases (BIO 37.7% and ICT 50.4%) after 2000. Many companies in biotech does not have turnover at all or it is very marginal due to early phase of R&D. It seems that firms investing heavily in R&D do not have in many cases a history of high growth which could support their future growth estimations. The qualitative information studied reveal that in many cases companies are creating the markets for new products. These innovations have been the basis of establishing the company. This means that – especially in biotech – the track record of the company do not stretch far.

Future R&D investments (H6)

Project related future R&D investment is very powerful variable. In the Model 1 with size factor included it is statistically significant only in ICT sample. In Model 2 in all three dataset it was highly significant. The comparison of beta coefficients reveal that especially in ALL DATA and BIO it had very strong position. Naturally in ICT it is also important but the predicting power of ICT model is lower i.e. the money companies are willing to invest is not as good predictor of the target turnover level than it is in BIO dataset. It is possible that the prediction power of the BIO data in Model 2 would be lower if more observations would be included but it is also good to remember that the investment environment of biotech companies is quite different from the environment of ICT. The investments needed to achieve a certain milestone in R&D in biotech are in a different level than in ICT. In that perspective it is natural that the future investments are more powerful interpreter in biotech than in ICT.

Company age (H7)

In Model 1 company age is not statistically significant variable, although in both sector samples the sign of the variable is according to expectations. It is not a significant variable in the Model 2 either and the sign is negative in all except in BIO dataset. In ICT data the age distribution of the companies leans more towards younger age category (0-4 years) than in BIO where company age is more evenly distributed. In BIO data also companies formed earlier are very eager to grow. The mixed results are not surprising in this respect.

As a conclusion from the findings of the two regression models I found some support for venture capital involvement, past R&D costs, exports and hot market condition. Another important finding is that the future R&D investments hypothesis (H6) was supported by the all datasets in Model 2. By incorporating the future R&D investments in the model, very high amount of target turnover variance is explained (ALL DATA 64. %, BIO 65.9% and ICT 42.2%).

The results of Model 2 are interesting from the perspective of recent study by Hermans and Kauranen in 2003. They study the empirical impacts of intellectual capital on future sales of SMEs in biotechnology. By dividing the intellectual capital on three subgroups (human, structural and relational) and by composing a two stage econometric model (factor analysis, regression analysis) of their databank of bio companies described earlier they are able to explain the variations of future sales in 2001-2006 with the interactions between the three categories roughly by 70%. As a measure of human capital they use the total personnel, the education of the personnel and the business experience of the CEO. The structural capital is measured by research and development costs, patent intensity, and the age of the firm. Relational capital is divided in three groups: university collaboration intensity, sources of equity finance and sources of capital loan finance. Hermans and Kauranen refer also to a paper written by Deeds (2001) who emphasize that the main source of innovation potential is R&D expenditure of firms. From a biotech perspective both studies give support to the findings from this study when comparing the amount of variance explained by Hermans and the variables they used and on the other hand the emphasis by Deed on R&D as a source of innovation potential. The elements analyzed by Hermans and Kauranen concentrate more on company level and are based on judgements on potential value creation of companies. Biotech companies without track record are difficult to value and the model they present is one possibility when analyzing the growth potential of the companies. The findings here focus more on project level and give support to the significance of R&D as a measure of company growth potential. It also gives an additional model for a project based valuation of the companies which is interesting especially when companies have many R&D projects in their pipelines. It is worth noting that in ICT the Model 2 is not as good explaining the turnover variations as it is in biotech, but future R&D investments are also in ICT very important. When analyzing the results, the limitations of the study should be carefully kept in mind but in terms of the most relevant findings, the unrealistic level of turnover estimations in Model 1 and the future R&D investments in Model 2, the results should be quite reliable since the effect is so strong. The problem of heteroscedasticity and the dependency of the error term with the dependent variable still leave something to improve in the model design.

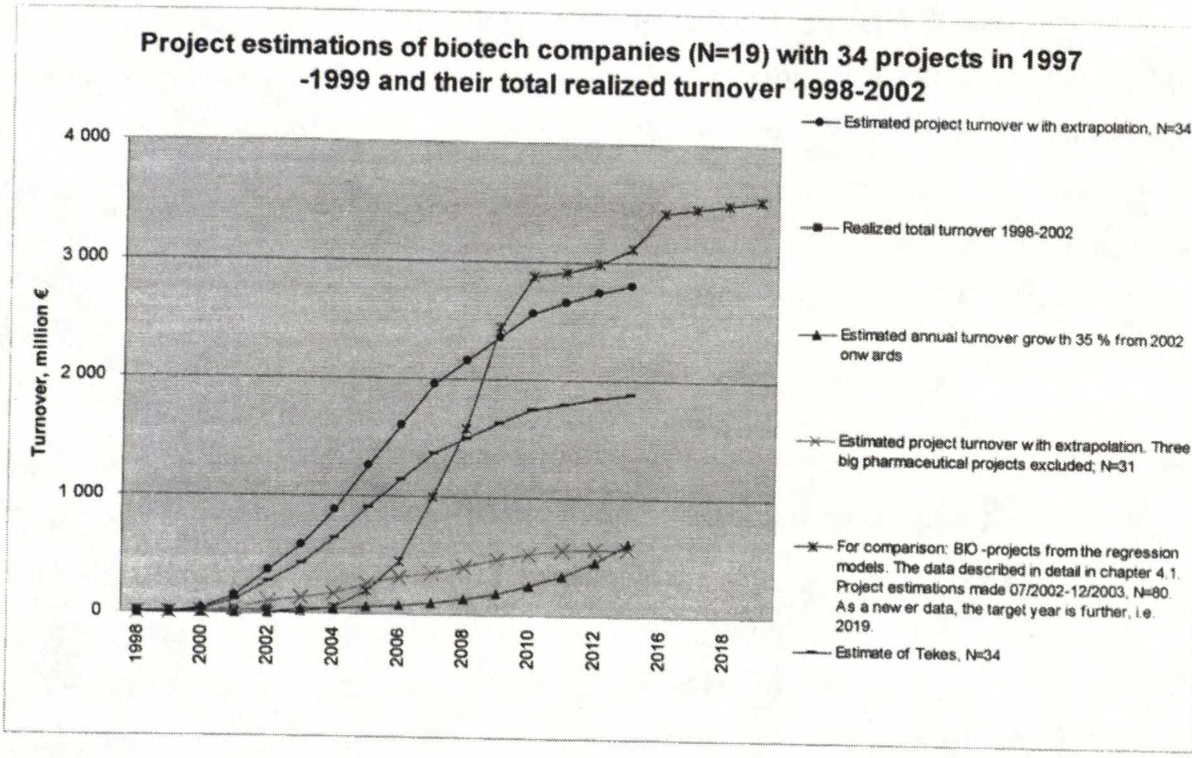
5.3 Retrospective view on project turnover estimations

So far the focus has been on future turnover estimations. In the following chapters I will try to illustrate how the estimations and the realized development have converged.

5.3.1 Past biotechnology company turnover development compared with expected estimates

The companies chosen from biotechnology area are companies from the *BIO* data – the data used in the earlier chapters - that have also projects in a earlier time span, i.e. 1997-1999. I have collected the target turnover estimations of their projects funded at that time period and compared project turnover estimations to the entire company turnover development. The reason why the project based estimation are compared to the total turnover development is that I do not have the information of realized project turnover development. On the other hand by asking the companies of their project development, the analysis would be dependent on their view and maybe not how things have actually developed. How do I then measure from the total turnover the part of sales realized from projects? I will not attend to do it, because it is very likely that the turnover estimates done in 1997-1999 are not realized like expected in the first place and in addition the overall turnover level of the companies in question was low. In the Figure 9 is shown how the companies' (N=19, 36% of the BIO regression model companies) projected sales or milestone payments and royalties for 34 projects was supposed to realize. Many companies have had more than one project and some of the projects have been financed in a row making the selection problematic. Project selection is quite conservative in order to avoid selecting the same project twice. Cases with reasonable certitude are accepted. I have also done a similar interpolation for the years between market + 2 years and the target year than in the BIO data. The turnover is estimated to grow linearly until the target year. This assumption is tilted towards the probability of a success and the timing of revenues is probably too early when linear assumption chosen. The turnover in years after target year is supposed to stay in the same level as in target year due to patent protection. The overall setting of the graph gives an idea of how the expectations game works in the industry. The realized turnover development has been quite marginal compared to the expectations. The high turnover estimations are from pharmaceutical companies and the realized revenues in 1998-2002 are mainly from other companies in the industry than from pharmaceutical companies.

Figure 9.



Hermans in his recent study (2004) constructed an econometric forecast model based on probability distribution of possible turnover outcomes of biotech companies instead relying on point estimates given by companies. Based on the model the annual growth of the biotech SMEs would be between 2002-2006 19% – 35% and the value added 125 – 309 million euros in 2006 with 90% probability. In the graph the growth rate of the upper bound (35%) of Hermans study is used to demonstrate how the total turnover of the companies would develop compared with the project estimations. 35% growth rate is very high in generally for an industry to grow as a whole. In this graph the project target estimations - put forward by the companies in 1997-1999 – and the total turnover development of the companies with 35% annual growth rate will reach each other in 2015 if three major pharmaceutical projects are excluded. The graph concretizes the option like feature of pharmaceutical industry within biotech industry. Few blockbuster projects are expected to yield immense returns in the long run. The graph shows how the expectations have not realized yet in the scale planned in the end of 1990's. The deviation from the expectations and the reality has brought the industry in the public discussion in Finland in spring 2004. Even if the assumption of linearity in the increase of sales between market entry years and the target year is positively skewed it is clear that the time-to-market has been longer than what was expected in some pharmaceutical companies. Naturally it is good to keep in mind that the companies analyzed here do include only a portion of the total population of biotechnology companies but from pharmaceutical companies all major sme's are included. In other words it describes quite well how pharmaceutical companies have planned their market entry. The development of turnover estimations is dependent on few projects with extremely high expectations. When three major projects are excluded, the situation changes fundamentally; the estimated turnover decreases drastically.

For illustrative purposes the turnover estimates from the regression model (BIO data) is added in the graph since the company data from 1997-1999 is a subset of companies from the BIO data. In the BIO sample the turnover estimations are made in 07/2002 – 12/2003. The level of turnover of BIO data in the graph is higher than in the projects funded 1997-1999 because of higher number of projects funded. However, in the individual project estimations the target turnover figures have decreased in the drug development projects. Some of the projects have received funding in both time periods and the same trend is seen also in these cases. This indicates that in the early phase of the industry development the target estimates where higher in the pharmaceutical projects. Also the timing of market entry has postponed in the blockbuster projects. In spite of the problems the pharmaceutical industry has faced, there are still many projects where the expectations are high. In terms of whether the projects will succeed or not, the time is not yet right to make conclusions. The development time of a R&D project in pharmaceuticals is generally considered to take a decade. Projects started in 1997 should have penetrated the markets in 2007. The data show a similar trend from the project estimations. The two peaks in target turnovers are in 2007 and 2010 for projects funded in 1997-1999. For BIO data the common target year is 2009-2010. The estimates made by Tekes are considerably lower than the estimates of the companies but the outcome of the pharmaceutical projects naturally dominates also in this case.

The billion dollar question in the pharmaceutical industry is whether the companies are able first of all to succeed with their pipeline projects and if they can, how much will they get as milestone payments and finally how much will they make from royalties. The likelihood of a success of an individual project does not rise up from probability distributions. If pharmaceutical companies succeed in their projects, the growth rate of the industry could be higher than 19% - 35% estimated by Hermans (2004). Of course it is clear that not all the projects will succeed but the key question is whether the right ones succeed. Hermans and Ylä-Anttila (2004) have come to a conclusion that it will take 15-30 years until the value added of the industry as a whole could achieve the present level of electronics or the forest industry. It is reasonable to believe that this will be the case. The project data presented in this study should give also answers to the timing of the possible breakthroughs. Positive news from the industry has increased this spring (2004) and the proof-of-finance (POF) has been easier to reach than in the aftermath of the year 2000. The project data presented in this study should be one of the cornerstones of the industry growth in the next decade.

It is interesting to see whether biotechnology industry will be the famous "fourth pillar" of the Finnish economy as so many have suggested. When considering an industry as a pillar, the production capability is usually the measure. Similarly, Hermans and Ylä-Anttila (2004) have made their estimations based on very high increase in domestic production of biotechnology. The question left untouched is whether biotechnology is an industry where the production itself is important part of the strategies of Finnish companies. In the strategies of pharmaceutical companies it is not, in other fields like diagnostics, industrial enzymes, biomaterials and bioprocesses, nutrition and agribusiness probably yes.

The studies made by ETLA recently (Hermans and Ylä-Anttila, 2004) suggest that the growth of the industry will generate from mixing new and old e.g. forest industry and industrial enzymes. Another tempting collaboration is between ICT and biotechnology in its many forms. These are probably only few of the possible outcomes. The advancement of science is so rapid that it is obvious that there's more to come. I believe that in the near future (in a decade at least) the Finnish biotechnology industry will be driven by biomaterial, pharmaceutical and diagnostic companies. Biomaterial companies are already increasing their sales and the future looks very promising, pharmaceutical companies like mentioned earlier are still in the chase of a breakthrough but already now there is seen some light in the pipelines. Diagnostics is in Finland very interesting sector because. Due to relative homogeneity of Finnish population and the health care system there are business possibilities waiting to be discovered.

5.3.2 History data on realized and estimated R&D project related turnover development of ICT firms

In biotechnology the focus of a retrospective view was between the overall turnover development and the expectations of the projects. In this chapter the view is more specific. The turnover estimates made in an application phase is compared to the realized development of the same project. Tekes follows the development of the companies after projects have ended. In May 2003 1827 copies of follow-up questionnaires was sent out to projects ended in 2000. The response rate was 70.23%. Altogether 300 replies of SMEs were received. From ICT sector 79 responses (26.3% from all SMEs) were received. The response rate in ICT sector was weaker (48.8%) than in average in the whole sample. The respondents were asked to fill a 5 page questionnaire with questions concerning the development of the project after 2000. They were asked to evaluate how the project had succeeded from a technological and commercial point of view. Respondents also evaluated how the project specific turnover development had succeeded in 2000-2003. In addition, they were asked again the market entry and target year turnover estimates for the projects. From a technological point of view the ICT projects succeeded well; 86.1% saw that the project had succeeded quite well, well or extremely well. The commercial potential of the projects was not realized as well as the technological objectives. 48.1% of the projects succeeded commercially quite well, well or extremely well but only 19% of the respondents stated that the commercialisation had succeeded well or extremely well. 2.5% of the respondents replied that the commercial phase was ahead.

The same trend is seen from the next figure (Fig. 10) where the application phase turnover estimate and the follow-up data is compared[16]. It is good to bear in mind that the projects analyzed here are a sample from the golden age of ICT i.e. from the end of 1990's when the expectation game was highest in the industry. The data included two projects with very high hopes for the years to come after the turn of the century. The other one raised millions of euros from Finland and abroad. The initial strategy was to sell products to a totally new business area worldwide. Shortly after the strategy was changed to include only Europe and

[16] The steep slope of the estimated turnover figures from 2003 onwards is due to hypothesis that after the target year of the project turnover level is zero due to short product cycle in ICT. This is probably too harsh hypothesis while the sales will most likely follow a gentle slope but it is difficult to determine a right slope. However, from 2003 onwards companies have estimated quite linear curve for sales level which would indicate that the decrease in sales does not happen directly after the target year.

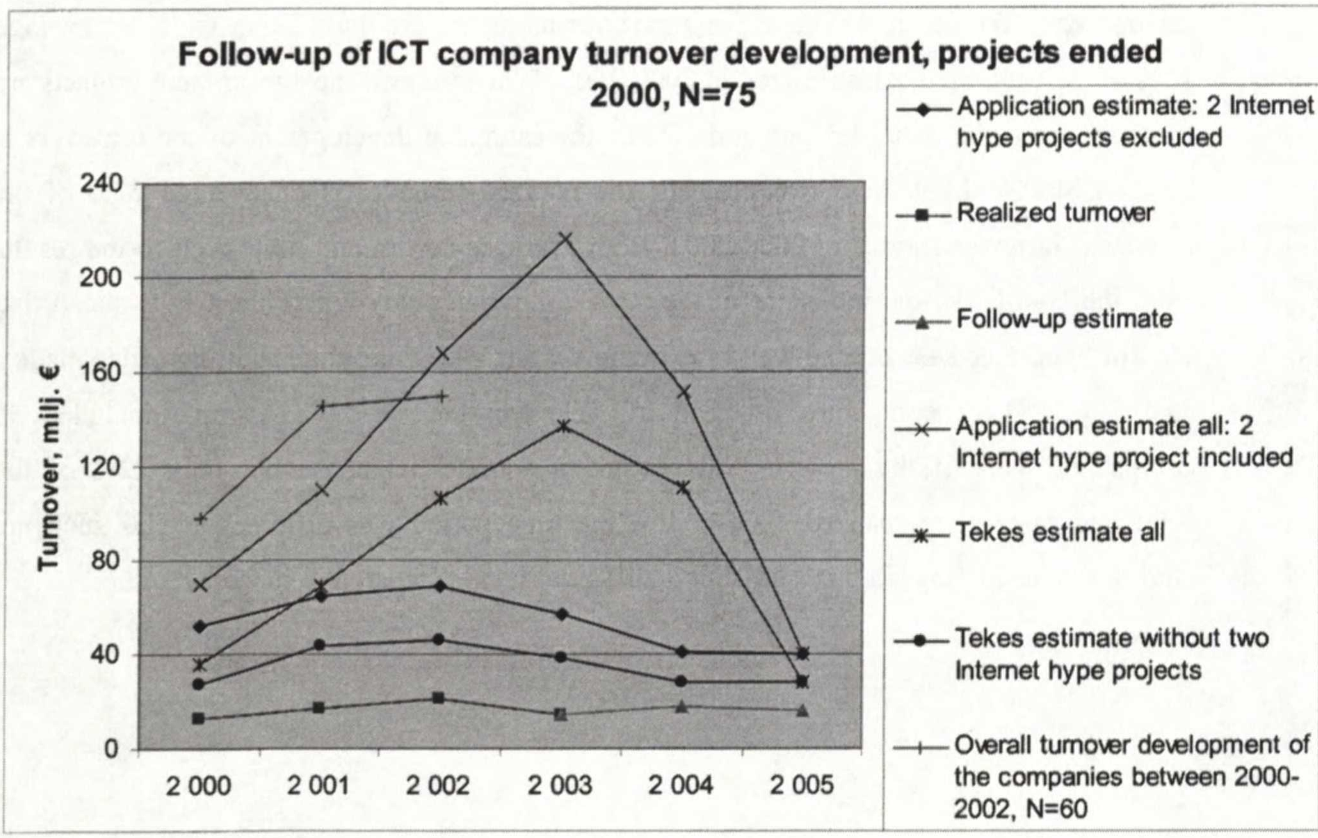
later on the company had to decrease the staff by half. It is still expected that the target markets are in billion euros but in the individual company level the target has been set to a fraction from the original. The expectations versus reality are quite harsh while on average 13% of the estimated sales realized in 2000-2003. When the two most prominent projects are excluded from the data plus one additional[17] the estimated development of the turnovers is quite stable. Without these two projects, the realized turnover is on average 27% of the estimated turnover figures in 2000-2003. Both averages correspond quite well to the results from the qualitative questionnaire of the same follow-up study where the CEOs stated that 19% of the projects succeeded well or extremely well. VTV[18] i.e. state auditing office made a study in 1991 of companies financed by Tekes in the 80's. The sample included 50 companies. 54% of the projects had reached a commercial phase but only 22% of the estimated sales were realized.[19] Of course the time period was different and as such not comparable to findings in this study but it still gives an idea where the success rate lies.

[17] Also a third project was excluded because its impact in application phase was significant but the respondent was not able to define the turnover share of the project from the total company turnover. The project was part of their core business but the outcome itself was just an appliance included in their products.

[18] VTV, abbreviation for Valtiontalouden tarkastusvirasto in Finnish

[19] Valtiontalouden tarkastusvirasto. Teollisuuden tutkimus- ja tuotekehitystoiminnan edistäminen. Tarkastuskertomus 1991.

Figure 10.



In Tekes during the evaluation process the sales estimations proposed by the companies were lowered. In the Figure 10 it is possible to see that on average 22% of the sales estimated by Tekes experts was achieved. If the two Internet hype projects are excluded the percentage is much higher resulting to 64%. In practise this means that the companies themselves present extremely high growth estimates to an investor which will cut them down to a more reasonable level. It is reasonable to believe that the overall realized sales per cent is lower due to sample problems. Non-respondents include also companies that had gone bankruptcy; 7.5 % of the companies in the ICT data (162 projects, 142 companies) had declared bankrupt between years 2000-2003. This would indicate that the sample is positively biased. The bankruptcy rate indicates also that the ICT projects were quite risky. The results are in line with the downturn in ICT business during years 2000-2003. One could also question whether only those with somewhat positive news of the projects would return the questionnaire while the response rate in ICT was considerably lower than in the whole sample. However, it is easily seen that the success or failure of few star projects has a significant impact on the return the investor - in this case Tekes - will receive. Naturally, achieved turnover level of companies is only one measure of the impact of R&D investments made by Tekes but it is certainly one of the most important when comparing the investment of 9,5 million euros to the results obtained from the 79 ICT R&D projects studied here.

In the follow-up study the estimations made in 2003 for the last two years are 43% and 41% from the original estimations. This means that the CEO's of the companies have decreased substantially their estimates for forthcoming years. The starting point estimates have been overly positive in contrast to realized development. The estimates for the future in this checkpoint are more cautious. The shortest line in the graph presents the overall turnover development of the companies 2000-2002. The level of the realized total sales level indicates that the R&D project outcomes have had a marginal effect on companies total turnover i.e. in the aggregate level the influence has not been significant, only 11-14% yearly[20].

The reasons for the lower realized turnover development are various. The R&D phase was longer than expected, marketing strategy failed, or the value chain was too complicated in the end. Other reason mentioned were problems with the customer. Key customer withdrew from the project and in some cases the project was not able to solve the problems customer had. Also the market penetration to foreign markets was difficult. The weak market situation in ICT in 2000-2003 weakened the market entry possibilities of the projects. According to responses also one important factor affecting the project outcome was the resigning of key personnel. In some cases markets were not mature yet for the project outcomes. Also the lack of standards was seen problematic. One very common explanation was the lack of financial resources which either had stopped the development or slowed it down. In this context it is quite understandable that 46.9% of the companies respondent that the significance of Tekes was great or extremely great for the individual company.

This small ICT sample illustrates quite well the overall development of the industry after the hype years. The sector had high hopes in the end of the previous decade and after year 2000 has suffered from the overall market downturn and in addition the ICT sector itself has been quite weak in Finland. There is only a small group of very successful telecommunication companies and the software business itself is very competitive and the companies involved

[20] 75 projects included 67 companies of which 60 companies had informed their revenue figures to the Suomen Asiakastieto Oy.

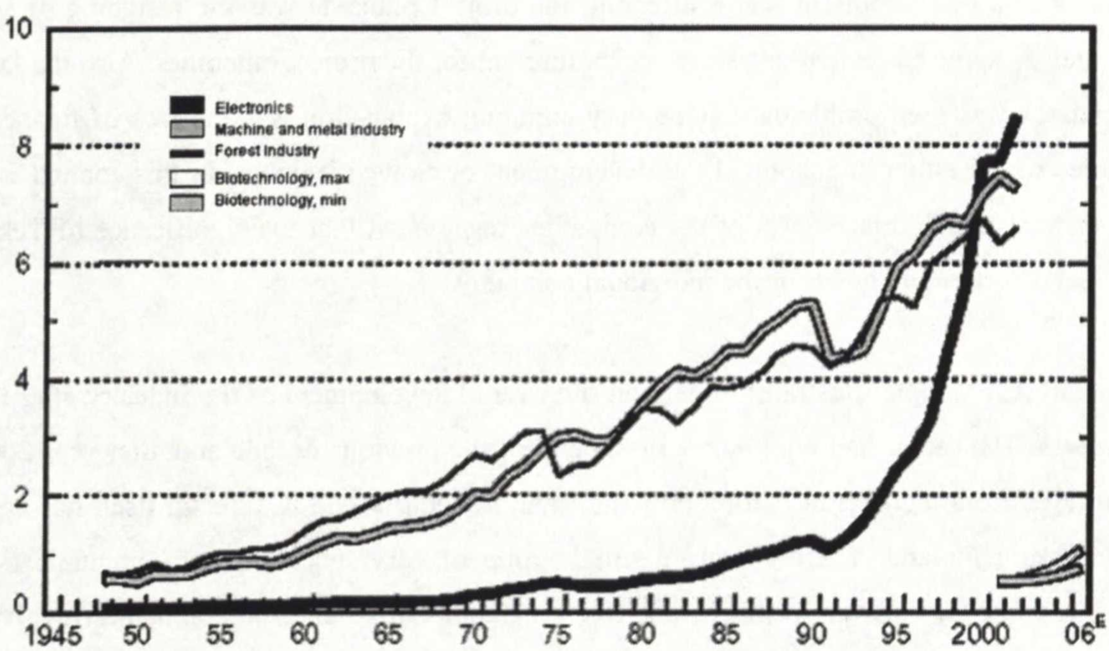
are quite small. This sample is illustrative of the expectation game in the high-tech business since new technology combined with overall market bubble will produce extremely high sales estimates. Typically for this sector only few star companies are expected to do a major part of the sales estimates. In this case they did not live up to the expectations – at least not yet.

5.4 The expectation game: the comparison of the two high tech industries based on the results

Naturally the overall economic impact of ICT companies on Finnish economy is totally different than biotechnology's so far. In Figure 11 is the industrial production of electronics (elektroniikkateollisuus), machine and metal industry (kone- ja metallituoteteollisuus), forest industry (sellu- ja paperiteollisuus) and partly estimated development of biotechnology industry (bioteollisuus). The estimated growth of biotechnology done by Hermans and Ylä-Anttila from a value added point of view is quite marginal until 2006 although the annual growth rate is projected to be for the whole sector about 10 - 18 per cent. The impact of ICT industry in the graph without Nokia would be totally different.

Figure 11.

Industrial production in Finland divided in industrial branches 1948-2002, in 2000 prices, billion €.



Source: Hermans and Ylä-Anttila (2004).

The role of large companies is very significant when the growth of industries is studied. This means that also biotech industry needs significant industrial partners. Orion is a natural partner for small biotechnology firms. The problem is that Finland does not have big pharma companies - in a global scale Orion is relatively small company. One possible outcome in biotechnology in Finland is that the foreign big pharma companies buy small companies. From a production point of view I think that even if the SME companies in biotech could grow in Finnish ownership or under foreign multinational company, the development to the production scale will happen somewhere else. I would expect that some of the biomaterial, pharmaceutical or diagnostic companies will grow to well known R&D firms which will first licence its products out to the big pharma but after few or even one breakthrough starts to take its projects further away.

The ICT sector on the other hand is in a very interesting phase after the high growth of the 1990's and the turbulent years of 2000-2003. The ICT sector in a European scale has received positive news in 2004 and it is expected that the market forecast is now better than in previous few years. However, the market situation is challenging for ICT companies since realized sales have been under expectations. Similarly as in our research also now in summer 2004 some of the ICT firms are doing very well and the majority is suffering from trade cycles.

Both ICT and biotechnology industries in Finland are in an important phase. The biotechnology firms are waiting for major licensing deals to be signed and on the other hand to reach the proof-of-finance from investors. ICT industry is not anymore an emergent industry in Finland if measured by industrial production. With the help of Nokia the industry has gained a strong foothold in Finland. The question raised in Finland is nowadays whether it is useful to continue to support the biotechnology sector or concentrate on those areas where we have established position (e.g. ICT and forest industry) and especially where we have comparative advantage. The question is important because the biotechnology is heavily dependent on government support (Sitra, Tekes) and without their financial resources the companies are incapable to operate. The question should not be whether government will stop its finance on biotechnology but how to find the best fit in Finnish standards. Biotechnology is promising new area and Finland as an internationally well-known high technology nation could make use of its reputation also in biotechnology.

The expectations in biotechnology are very high but actually they are extremely high only in pharmaceuticals. The risk inhibited in pharmaceutical projects is high as are the investments needed to realize target turnovers. It is clear that those targets are not possible to be realized depending solely on government support. Collaboration agreements with the big pharma is a necessarily path for small Finnish bio companies. The comparative advantage changes in time, it is possible that biotechnology could be part of it some day but without domestic large company in international scale the path is co-operation with the global players. The expectation game in the Finnish pharmaceutical companies is rising. The industry needs breakthrough deals in order to justify used public support. As was shown earlier on, the R&D pipeline of pharmaceutical companies have promising projects which should materialize within 3-6 years. The situation is easier in the ICT for many reasons. The industry has produced already its Nokia. Finland is known for its ICT, which - for example - facilitates foreign investments. Promising companies in ICT will prove the expectations right in a shorter interval than in biotechnology. Biotechnology is a game for big players but also smaller countries can survive like Sweden has demonstrated. You just have to prove the expectations right.

6. Conclusions

The focal point of this study was the expectation game of the two high technology sectors. Both ICT and biotechnology are considered as high technology industries with high growth potential. The data was gathered from the database of the National Technology Agency of Finland, Tekes. The study aimed at creating an econometric model which could explain the high turnover estimates of the companies which usually do not have a sufficient track record to back up the estimations put forward. The second challenge was to find out whether the revenue estimations have been realistic.

The results obtained show that the revenue estimations made by the companies are unrealistic. The first econometric model created (Model 1) supports the conclusion. When exports, involvement of a venture capitalist, past R&D expenses, future R&D investments are proportional to company size, the model explains in ALL DATA only 11% of the variance of target turnover. In ICT variables explained 16.6%. In biotech the Model 1 was not able to explain the turnover levels with the variables used. The results obtained from the retrospective data support the findings. In ICT, the Tekes follow-up data reveals that on average only 27% of the companies' expected turnover level is achieved. The ICT industry in Finland is known for few star companies which have managed well in the expectation game and on the other hand the majority of the companies especially in the software industry are struggling to survive. The retrospective data confirms that the turnover estimates of ICT R&D projects ended in year 2000 where set in an unrealistic level in spite of the fact that the influence of few projects is considerable in the data. It is also illustrative of the Internet-bubble and how the views of the market potential changed after year 2000. The realized effect of R&D projects on total turnover of the companies was only 11 – 14% yearly. Realistic level of the turnover estimates in ICT would be 20-30% of the original estimates. Most likely the turnover estimates have been done without any risk-adjusted measure. The failure of the companies with high growth estimates raises the question of the importance of the so-called middle road companies, which do not have extremely high growth prospects but are on a steady but long growth track and fulfil their growth estimates.

In biotechnology the target years of biotechnology companies have postponed from the years estimated in the early years of the industry. The target level of turnover has decreased in the drug development companies after the high expectations in the late 1990's. This reflects the overall development in other countries after year 2000. Few drug development companies have very high levels of target turnover which influence the industries aggregate levels considerable. The target turnover estimations of biotechnology have been optimistic from the point of view of timing and size. It is not surprising from the study point of view that the biotechnology companies are incurring now (summer 2004) problems. The expectation game was overheated in Finland in the late 90's and it is evident now that the industry is struggling to show commercial results. When the expectations have not realized like estimated, the investors and media particularly has started to question the rationale of the investments especially in the pharmaceutical industry which controls the movements in aggregate level in industry expectations. The study shows that the expectations have postponed and especially the level of pharmaceutical turnover estimates has decreased but in spite of that they still show high expectations for the future. It is clear that some disappointments will materialize but it is too early to say what will be the outcome in the industry in Finland. From the current point of view, years 2007-2010 will be decisive for the industry while the sales of current projects should be in peak level. However, the industry is now facing financial restrains which will have significant impact on future development of the companies.

The most important finding of the second model (Model 2) was that when the variable future absolute R&D investment was included, the model explained high amount of the variance of turnover estimates (All data 64.9%, BIO 64.9%, ICT 42.2%). This indicates that a typical high-tech company in the sample has high growth estimations backed by plans to invest a substantial amount of money on achieving the targets. The higher the future R&D investment, the higher the sales revenue targeted. The turnover estimations were independent of the size of the companies which means that future R&D investments compared to company size were in unrealistic levels like Model 1 suggested. One reason for high future R&D investment compared to company size is that companies have calculated the possible grant or debt from Tekes into the budget. This means that the role of Tekes is important when considering the possibilities of high tech companies to carry out the projects.

In the beginning, 9 research questions were put forward. From the questions 1-7, I found some support for venture capital involvement, past R&D costs, exports and hot market condition. The most significant impact on growth prospects however had future R&D investments. The results are in line with the research of Garner et al. (2002) where they showed that the larger the relative R&D investment, the greater the market value of the firm. The answer to research question 8 in biotech is that the great expectations have not realized yet, but they have actually postponed and decreased but still show high expectations. However, the presumption is that the expectations do not materialize as estimated due to absence of risk-adjusted measures in turnover estimates. In ICT the estimated turnover levels have been unrealistic; the realistic level would be 20-30 %. The answer to the last research question is that the major difference between the two industries is the length and level of expectations.

Suggestions based on the evidence found from this study concentrate on the management of the commercial phase of the R&D projects. Companies need to focus more resources on market analyses in order to have the fundamentals right in the turnover estimations. Technological success as such is not sufficient. Companies need to allocate more resources to the commercial phase of the product life cycle and Tekes needs to put more effort on assessing the market potential of the R&D projects and the capabilities of the SMEs to realize them. Tekes funding should be allocated more to the commercial side of the R&D projects but only in accordance with the directives of the European Union so that the public funding does not hamper competition between companies in the markets. Strong R&D needs viable commercial capabilities in order to survive. The recent actions made by Tekes are steps to the right direction but needs to be strengthened more also in the long run. One very important remark, which I would like to stress here, is that foreign venture capital investor involvement was scarce in both industry sectors. I believe that it is one reason for problems in commercial phase especially when companies are aiming for international markets

What would be an ideal type of growth oriented high tech company based on this study? The most promising would be a company with high share of exports i.e. a company which is internationally oriented, has a venture capitalist to speed up the development and invests now and in the future in R&D in order to keep up in the competition. On the other hand, the investments should be in line with the resources of the company and there should be money left to penetrate the markets with the outcomes of the R&D pipeline. The target of high tech firms is first high growth and then later on sufficient level of profitability. The results are in contrast with the study of Kamshad and Hay (1996) where they found that the new technology based firms target first profits instead of growth. One reason could be that the customer profile in Tekes is more growth oriented than in all population of high tech companies.

Future studies in the field would include a study of the success rate of the venture capitalists in their high tech company investments in Finland. The field in Finland is from the scientific point of view quite sparsely researched. The main problem is the availability of the data since venture capitalists do not publicly disclose information on such matters. Another interesting research topic would be to study in larger scale companies that have lived up to the expectations i.e. what have been the critical factors of success. From a Tekes point of view it would be also interesting to study how Tekes has succeeded in all the industry sectors. Studies in Tekes are made possible by the accumulating knowledge of follow-up data in the coming years. Naturally an update of this research after few years would also be interesting especially in the biotechnology where the expectations have not yet materialized.

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